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Forthcoming Event.

OCTOBER 10.

British Foundrymen's Association (London Branch).—"Methods of Reducing Patternmaking Costs," by D. Gordon.

NOTES AND COMMENTS.

Cupola Controversies.

There is probably no question in regard to cupola working on which opinion is so much divided as on the question of "drop bottom *v.* solid bottom." We have in these two types represented the old-established English practice (the solid bottom), and what is generally regarded as the American type (the drop bottom), though the latter has now become a feature of many English designs. Disputants on the virtues of these two types respectively put forward various contentions in favour of or against each, so it may be interesting to briefly review those contentions and examine their validity. The advantages claimed for the drop bottom are:—(1) The hinged bottom, on being released, allows all the contents to fall out at once, whereas with a solid bottom the charge remaining after a day's work has to be raked out by hand—a laborious and hot operation, occupying from ten to fifteen minutes; (2) the contents can be discharged unmelted or partly melted, along with the partly burnt coke and the slag, and if water is thrown on to cool the mass, the valuable constituents can be separated and used again next day; whereas with the solid bottom it is necessary to melt the superfluous metal so that it can be run out, this involving so much extra coke consumption; (3) no fuel is used to maintain the heat while drawing out, as is sometimes the practice with solid-bottom cupolas; (4) the drop bottom allows easier access to the interior for the repairs, etc. So much for the advantages; but the opponents of the drop bottom claim the following disadvantages as compared with the solid bottom:—(1) The sand bottom has to be re-made entirely each time the cupola is started, whereas only about one-third of the solid bottom requires renewing; (2) there is more moisture to be dried out, and the furnace becomes generally colder than with a solid bottom; (3) there is a greater tendency for the first metal down to be hard through the chilling effects of an imperfectly dried bottom; (4) there is always the possibility of a leakage of metal if the bottom is not made thoroughly sound.

It will thus be seen that the relative desirability of either style of furnace must depend on the relative importance of the factors named in the particular case. For example, the comparative safety of the solid bottom is considered by many to quite off-set the facility of dumping afforded by the drop bottom. The amount of metal to be melted down before drawing a solid-bottom furnace, too, may be negligible, and in some cases may be utilised by pouring into catsings, perhaps into permanent moulds for stock castings. In such case the cake consumed is not wasted. Nor is fuel in all cases required to maintain the heat while drawing out a solid-bottom furnace. Also, as regards access to the interior, the solid-bottom design is claimed to afford better facilities for clearing obstinate portions hanging to the sides, only the tuyeres being available for the introduction of a bar in the case of a drop bottom, as against the open front through which the contents are drawn in the solid-bottom furnace.

Taking next the disadvantages of the drop-bottom design, the extra labour of making up the bottom and the extra trouble in drying are offset by the ease of dumping and the saving in coke and metal there effected. The great consideration in the minds of many is what is involved in the case of a leakage with a drop bottom. When that does occur, probably the best procedure is to at once stop the blast, drain the cupola of metal and slag, cool the doors with water sprinkled on, so as to solidify the metal, and then proceed again with blowing, when probably no more trouble will be experienced. This, or some similar procedure, is usually recommended. True, the manual labour involved in such a case is considerable, but the occurrence is by no means frequent if care is exercised in keeping the lining free from slag and in making up the bottom properly.

It would appear, then, that the importance of the different objections to a particular style of cupola is greatly affected by the competence of the furnaceman and the amount of care exercised in conforming to the requirements. Where any carelessness is likely to be experienced, probably the solid bottom is preferable, despite any extra labour involved, and where both styles are operated with strict regularity and care, probably the drop bottom would be found on comparison to be the most economical in labour and coke. But here we come against the difficulty that such a thing as a careless furnaceman is not yet an impossibility, and that is where the solid bottom keeps a hold on the affections of the foundry foreman. We do not think that in view of the other frequent sources of waste in cupola working the possible economy of one style of bottom over the other is of such great importance as often suggested, for as mentioned, a saving in one direction is largely offset by greater consumption in another. It is a simple matter to save a few pounds a year by a drop bottom and waste many times that amount through incorrect tuyere area and blast quantity. One is probably safest in recommending those who have doubts as to the safety or convenience of either type to continue with the other furnace and direct their attention to the greater economies possible in other directions.

Adaptability in Craftmanship.

A tendency in many trades, which has become more prominent in recent years, is towards increased restriction in line of operation and materials employed by the one craftsman. Specialisation is inclined to engender a lack of adaptability in the methods and processes conducted by one man and restriction in the materials he employs, the range within which he can work being distinctly circumscribed. Frequently, however, a particular result can be obtained by two or more quite distinct processes, and according to the nature of the process employed the work is considered as belonging to one or another distinct craft or trade. To some extent this attitude is quite justifiable, as tending towards economy in production. But as is too often the case where economy is carried to extremes, too rigid an attitude on this matter may involve waste instead. "Let the cobbler stick to his last," but also let him know all the various means whereby his boot may be made, and the different processes whereby economy in production may be secured.

In pattern-making, perhaps, more than some other branches of engineering, there is a marked tendency to disregard alternative methods, though often a departure into what at first appears to be the realm of another trade, may easily secure much saving in time, trouble, and material. An example of this is given in the article which appears on another page of this issue, in which the author discusses the application of modelling and plaster work for ornamental patterns. The woodworker is here ruled out entirely, though it would be very incorrect to say that the process does not come within the scope of the patternmaker's art. True it is that plaster-of-Paris has of late years found more favour in the production of patterns; but it has often been employed under protest from the devotee of pine and bay-wood.

Since, however, it is obviously desirable to limit, for practical reasons, the variety of work to be undertaken by one man, we may enquire as to what shall set the circumscription. As a general principle it is safe to state that a craftsman is justified in employing for the attainment of a certain end in his work, the most suitable or economical of any materials or processes available, regardless of whether the processes or materials in question are employed in any other trade. This, of course, is the broad principle which has governed the selection of methods and materials in the development of practically all trades; but the constant changes which accompany the evolution of industry are continually bringing new possibilities before different trades, or changing the relations which those trades bear to existing possibilities. There is, of course, the difficulty that a man trained to use certain materials cannot always readily make the best use of a new material, and consequently he sticks to the old. But this does not discount the value of that adaptability which acknowledges no bonds of prejudice but applies to the attainment of an end the best of all the facilities available. In some cases the variety of methods and materials is such that, of necessity, they are divided between several distinct trades, each serving the same ultimate end; but that is outside the scope of what we have in mind.

The same circumscribed area of operation is, again, frequently found even when there are several processes operating side by side for the one end, as for example in moulding. It must be admitted, in extenuation of the moulder's limitations, that not many men to-day have opportunity afforded them of obtaining the experience of and insight into all the different branches of moulding work. But the fact remains that too large a proportion of moulders are not adaptable even within their own recognised orbit. When a specific piece of work goes into the foundry, too often the method of moulding, etc., is not controlled by the question of suitability, but by the limitations of the men who have to handle it. This is only natural in the circumstances, and until the moulder's trade is treated more as a skilled calling there is little hope for a change. As an example of what this means, however, may be taken the possibilities before the process of moulding in green sand from skeleton patterns and strickles. The blank lack of comprehension which some dry-sand moulders exhibit when the possibilities of this process are broached is really striking, though, perhaps, not surprising, since they often regard ordinary green-sand and loam work as beyond their range. Nevertheless, they may be doing work which would be far more cheaply turned out by the process mentioned.

It will, of course, be understood that in all trades there must be those who are more particularly competent in one or another direction; and this in itself is very desirable. But the rigid adherence to only one line of operation should not be allowed to override the application of the best method and material for the particular job. Special competence should be accompanied by a fair general competence within the full boundaries of the craft, so that each job may get something like the best treatment; in that competence lies the difference between the craftsman and the operative.

Making Flange Pipes, Cast Vertically, in Sand.

By Sidney G. Smith.

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In the following is described the procedure in making flange pipes from 24-in. and upwards, cast vertically in sand. The method of ramming and casting large flange pipes vertically has many

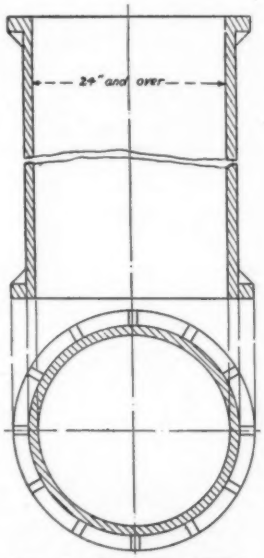


FIG. 1.—SKETCH OF PIPE TO BE MOULDED.

features in its favour, because when properly made with good tackle, a vertcally-cast circular casting will always be found sounder, cleaner and stronger than when cast horizontally. Many defects which

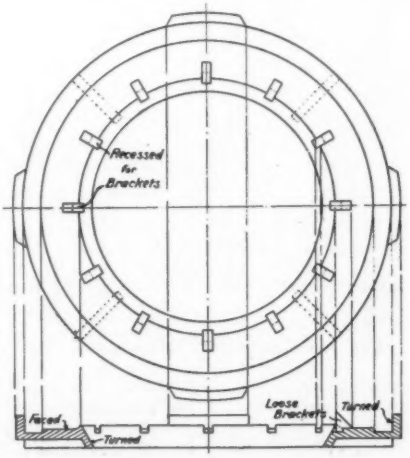


FIG. 3.—RAMMING PLATE (A, FIG. 2).

appear in castings poured horizontally disappear when cast vertically, and if the lay-out of this method is carried out in detail, it will be found economical, as the amout of waste work is very small. It is the writer's intention to be minute in detail regarding tackle, excepting dimensions, which must be according to the size of castings required.

Not less than $1\frac{1}{4}$ in. of sand should be allowed for ramming in large pipes. Flange pipes are rammed, dried with gas, and cast in an open pit in the same manner as ordinary socket-and-spigot pipes. The gas is carried from the producer through brick flues underneath the pit bottom.

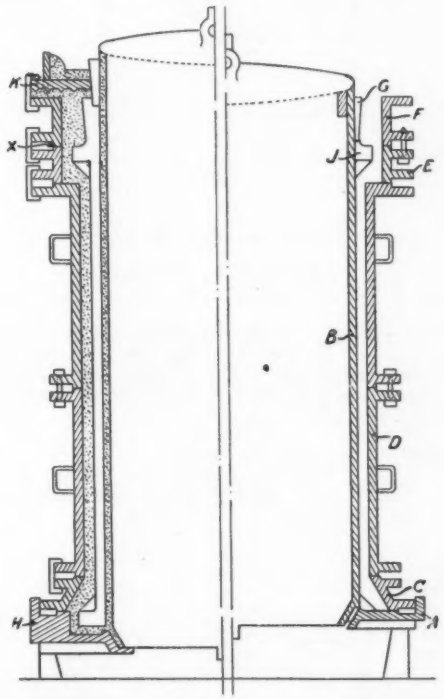


FIG. 2.—ASSEMBLED MOULD AND TACKLE. LEFT :—BOTTOM FLANGE PLATE WITH FLANGE STRUCK UP. RIGHT :—RAMMING PLATE IN POSITION.

Fig. 1 shows the pipe to be made. Fig. 2 shows in section the assembled mould and tackle. On the right is the ramming plate (Fig. 3) in position; on the left is the bottom flange plate (Fig. 10), with the flange struck up. Fig. 3 shows in plan and section the bottom ramming plate, which is turned and faced as indicated. Fig. 4 shows the body pattern, which is turned all over outside, Fig. 5 the bottom bell box, which is in halves and which encloses the bottom flange; Fig. 6 the main box, the top and bottom ends; Fig. 7 the matching piece which encircles the top flange; and Fig. 8 the head box which

carries the feeding head. The feeding-head pattern, which is made of wood, is shown in Fig. 9, and in Fig. 10 is depicted the bottom flange plate, on which the flange is struck up in loam. Fig. 11 shows the bottom flange plate, striking board, cross and

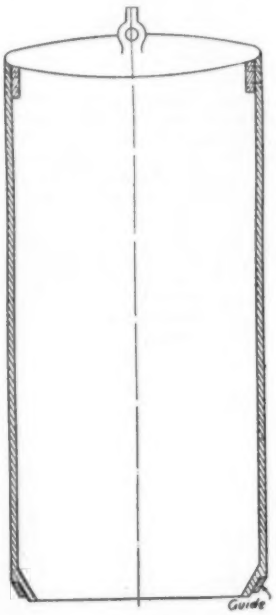


FIG. 4.—BODY PATTERN (B, FIG. 2).

spindle, and Fig 12 the top bracketed flange pattern, which is metal; while Fig. 13 shows the cake plate for closing in. All box joints are faced, the total length of the boxes determining the length of the pipe.

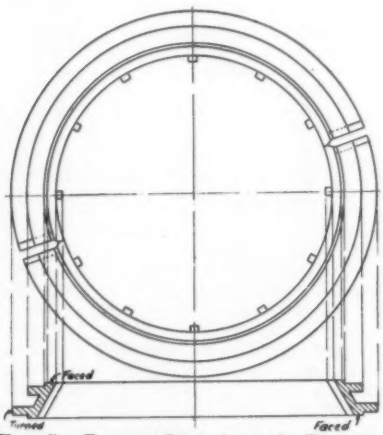


FIG. 5.—BOTTOM BELL BOX (C, FIG. 2).

When preparing to ram, the ramming plate, Fig. 3, is levelled and the body pattern, Fig.4, put on. The loose flange brackets are then put in their places, which are recessed in the ramming plate, after which the bottom bell box, Fig. 5, which is in halves, is cramped and put on the ramming plate. Prepared sand is put around the brackets and rammed, after which the main box, Fig. 6, which is

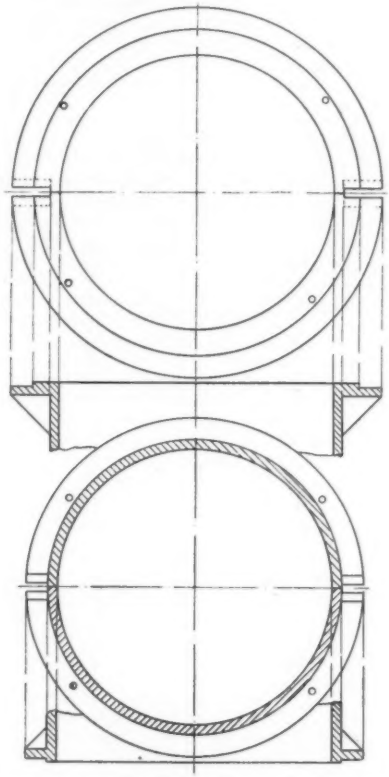


FIG. 6.—MAIN BOX; TOP AND BOTTOM ENDS (D, FIG. 2). ALL JOINTS FACED.

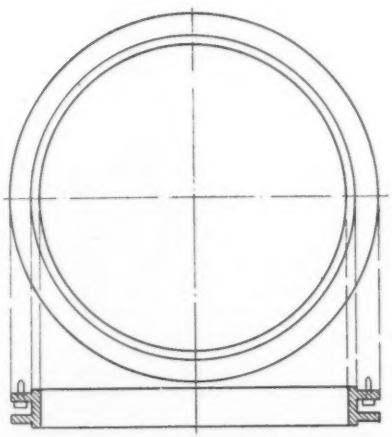


FIG. 7.—MATCHING PIECE (E, FIG. 2).

longitudinally in halves, is cramped and put on the bell box, centred to the pattern, cramped to the bell box and rammed with long rammers. The matching piece, Fig. 7, which takes in the top flange, is put on and cramped to the main box.

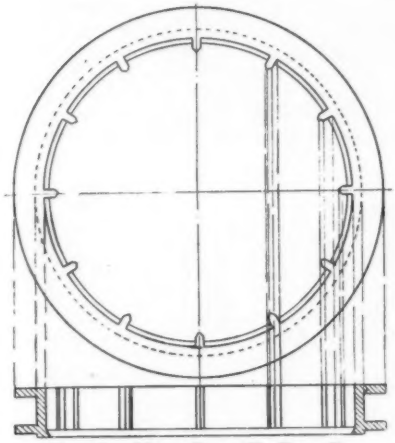


FIG. 8.—HEAD BOX (F, FIG. 2).

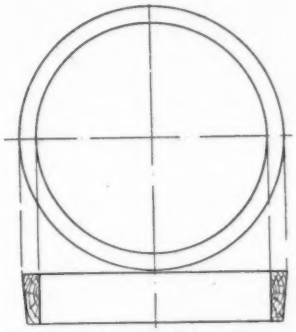


FIG. 9.—FEEDING-HEAD PATTERN (G. FIG. 2).

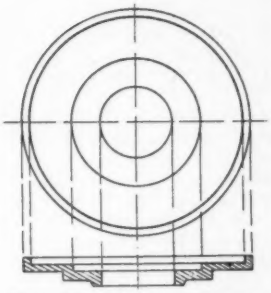


FIG. 14.—FLANGE PATTERN PLATE FOR PIPES 12IN. TO 24 IN.

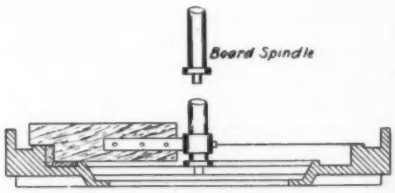


FIG. 11.—BOARD SET FOR SWEEPING BOTTOM FLANGE.

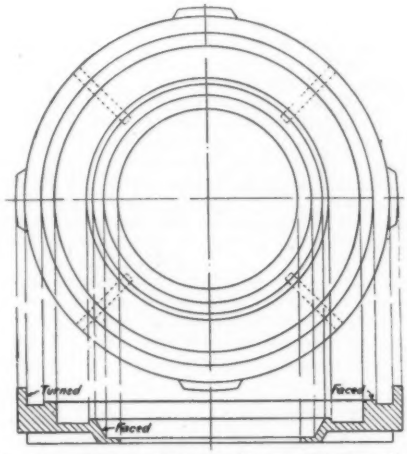


FIG. 10.—BOTTOM FLANGE PLATE (H, FIG. 2).

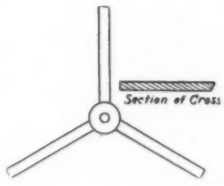


FIG. 11A.—SPINDLE CROSS.

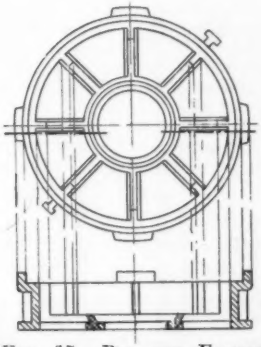


FIG. 15. BOX FOR FLANGE PATTERN PLATE.

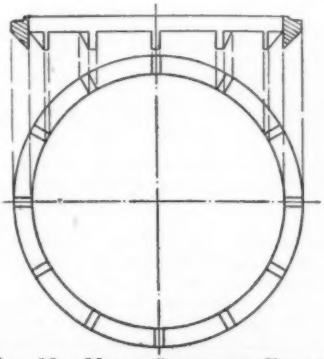


FIG. 12.—METAL BRACKETED FLANGE PATTERN (J, FIG. 2).

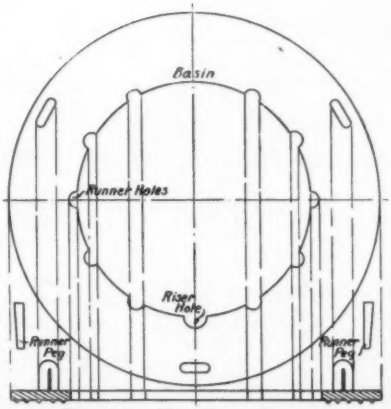


FIG. 13.—TOP CAKE PLATE.

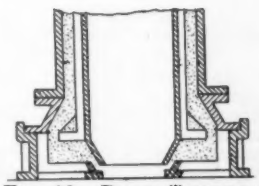


FIG. 16.—BOXES TOGETHER AND MOULD ASSEMBLED, FOR PIPES 12 IN. TO 23 IN.

The top flange pattern, Fig. 12, with brackets, which is cast in one piece, is passed over the body pattern, and bedded level with straight edge to the facing of the matching piece, which determines the length of the pipe. After being rammed, a joint is made at X, Fig. 2. The head box, Fig. 8, is put on to guide pins. The head pattern, Fig. 9, is passed over the body pattern to joint, rammed and sleeked level with the top of the head box. The body pattern is now withdrawn, after which the head pattern is withdrawn and the head box parted at joint X.

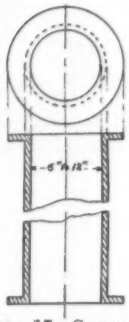


FIG. 17.—SKETCH OF PIPE TO BE MOULDED.

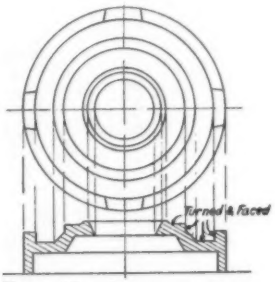


FIG. 19.—RAMMING PLATE (L, FIG. 18).

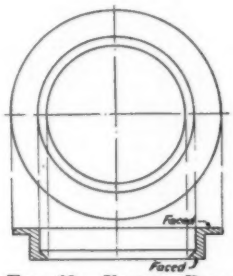


FIG. 20.—FLANGE RING (M, FIG. 18).

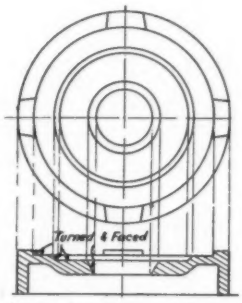


FIG. 21.—BOTTOM PLATE (N, FIG. 18).

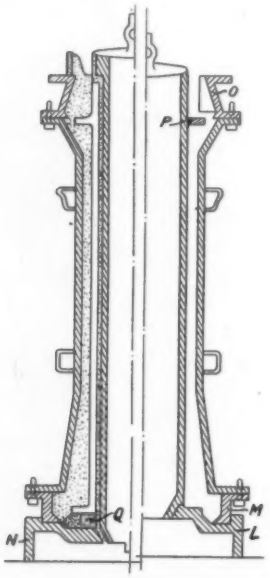


FIG. 18.—ASSEMBLED MOULD AND TACKLE FOR PIPES 6 IN. TO 12 IN.

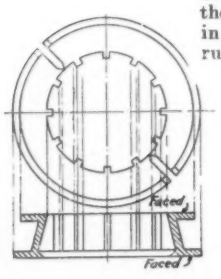


FIG. 22.—HEAD BOX (O. FIG. 18).

The top flange pattern is then withdrawn, and the main box lifted off the ramming plate; brackets and flanges are then finished, the mould blacked, the head box replaced and afterwards dried with gas fire or hot air.

The bottom flange plate, Fig. 10, is struck up in loam and should be well warmed before being roughed with clay loam, and when stiffened finished off with gas-tar loam. If cores are required to be cast in the flanges, a full-size template is used with check pieces fastened on for the bottom flange, the core prints cut out green, and prints cast on the top flange pattern. A guide is fixed near the top part of the body pattern for the top flange, and in the ramming plate seat and seat of the body pattern for the bottom flange, which ensures the holes and brackets aligning properly.

The core barrel, which may be a spring, key, or segment one, needs no banding; ¾-in. thickness of loam will be ample on the barrel, which should be liberated as soon as the metal is set. The barrel is first smeared with clay loam while warm, and when dry is roughed with medium loam and finished off with fine loam. These operations refer to the key hinge barrel. With spring and segment barrels, only one operation is needed if the barrel is warm enough.*

The core is struck up from a plain core board, which is more durable if made in metal fixed on journals which are adjustable, and which rest on stands. Large core barrels are sometimes struck up vertically, reference to which practice is made elsewhere.

When putting the mould together for pouring, the bottom flange plate, Fig. 10, is levelled on bearings, the main box, Fig. 6, is put on it, the core lowered in and centred, and the cake plate, Fig. 12, with runners passed over the body core on to the head box, closing in the mould. After being cramped to the head box and the runner box made up, the mould is ready for the metal.

FIG. 23.—TOP FLANGE PATTERN (P, FIG. 18).

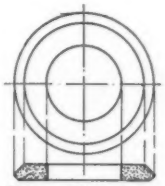


FIG. 24.—SAND CAKE FOR FLANGE (Q FIG. 18).

The only difference in procedure in making 12-in. to 24-in. flange pipes and those above 24 in. dia-

* The writer will deal in a separate article with core barrels of different types.

meter is that for those from 12 in. to 24 in. the bottom flanges are rammed in a box part from a flange pattern-plate in sand, instead of being struck up in loam as with the larger diameters. Fig. 14 shows the flange pattern-plate and Fig. 15 the box; while in Fig. 16 is shown the boxes together when the mould is assembled.

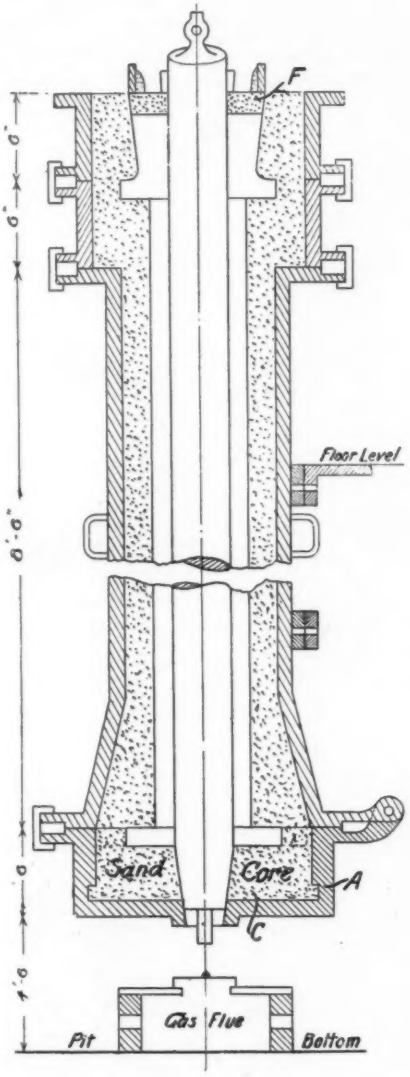


FIG. 25.—SECTIONAL VIEW OF ASSEMBLED MOULD AND TACKLE.

Flange Pipes from 6 ins. to 12 ins. Diameter, up to 12 ft. long, Cast Vertically.

Coming now to pipes of smaller diameters, the method of making is in many respects somewhat different. Fig. 18, on the right, shows in section the body pattern, boxes and ramming plate in position as rammed. On the left is shown the complete mould when ready for pouring. Fig. 19 shows the ramming plate L; Fig. 20 the bottom flange ring M; Fig. 21 the bottom plate N; Fig. 22 the head box O; Fig. 23 the top flange pattern P; and Fig. 24 the sand cake Q.

The procedure in ramming and drying is the same as with the larger diameters. The boxes may either be hinged or in halves. It will be noted that the ramming plate L and the bottom plate N are quite different from the arrangement in the larger diameters. The bottom face of the bottom flange is formed with a sand cake Q (Figs. 18 and 24), which is V-shaped on the outside edge. The bottom plate N is recessed to fit half the depth of the sand cake; the half in depth is formed by the bottom joint shown on the ramming plate L. The bottom ring M only need be a shallow one, and after being rammed is cottered on to the bottom flange of the main box. The head box O, after ramming, is parted to draw the top flange pattern P. After being blacked it is replaced with pin guides, and either cottered or cramped.

It will be noted that the head is the same thickness as the pipe, which in the case of light sections with suitable iron and sufficient depth of head will be found satisfactory; but in no case, whether in thin or thick sections, must the head be thicker at the bottom or root than at the top It is good practice to have the head thicker at the top than at the bottom, for if the head is thicker at the bottom it will remain liquid longer, and consequently the liquid shrinkage will draw away from it downwards, and the top of the head being thinner and setting sooner will draw away upwards leaving the top face of the flange in a spongy, unsound condition. It is well to bear always this in mind.

It will also be noted that the shoulder of the core barrel terminates the head. The barrel is neither a key spring nor a collapsible one, nor is it banded, but struck up with open, perishable mixture of manure and weak loam, the striking loam being of only sufficient strength to resist the pressure of the liquid iron when pouring. The thickness of sand between the body pattern and the main box need not be more than 1 in. If trouble is experienced with dirty or unsound top flanges, the head must be increased in thickness, or depth; both may sometimes be found necessary.

Flange Pipes from 3 ins. to 6 ins. inclusive, Cast Vertically.

The following are details of the procedure in making vertically-cast flange pipes from 3 ins., 6 ins., inclusive. When making 3-in. or 4-in. flange pipes 9 ft. long in large quantities, it is economical to use fixed boxes, *i.e.*, the boxes are hinged and one half is bolted on the side of the pit, either round, retangular, or any desired shape, provision in the way of brackets having been made in one half of the box. The box is then a permanent fixture for ramming, drying, pouring and stripping. This plan avoids much lifting, setting of boxes, and crane work. It also economises space, wear of tackle, lessens breakages and is altogether a safe way of working.

When this plan is in operation the long length of box is cramped on the opposite side to the hinges. The bottom box (A, Fig. 25), which carries the bottom-flange sand core, is also hinged to the long length. In this box is also inserted the ramming plate when ramming the pipe, on which the pipe pattern rests (B, Fig. 27).

When the pipe is rammed and the pattern drawn, the bottom box A is released from its fastenings,

which may be either cotters or cramps, on to its hinges, and then swings quite clear of the straight mould. The ramming plate is then removed to the next box and ramming continued as before. When the moulds are dried, which is done by gas, the sand-core cake (C, Fig. 25), which forms the bottom flange, is inserted into the bottom box A, and is a true fit.

The body-core seat is also formed in this cake, and in it the body core rests and carries its weight. When

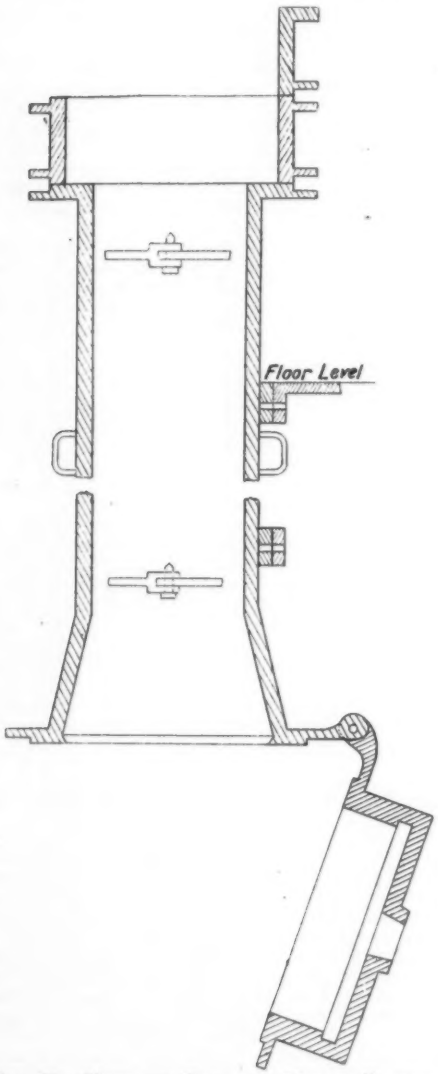


FIG. 26.—MOULDING BOX WITH HINGED BOTTOM PART.

the hinged box is lifted up and cramped it is self-centred by two short guide pins (see Fig. 28), and is ready to receive the bottom core, as shown at C, Fig. 25.

There is no need to repeat what has been previously explained in former articles regarding methods. The chief difference between the small flange pipes and the larger ones is in the bottom arrangements of flange and boxes. In the methods described in former articles the bottom of the pipe and flange is rammed in a separate box on a ramming plate called the bell box and bottom-flange box In the present procedure the bottom flange is formed by a dry-sand core rammed in a iron core box and put into the bottom-flange box which is hinged to the main box. This core box and bottom-flange box are fully described by the sketches. The bell box is unnecessary in these pipes, as it is rare that brackets are required on 3- or 4-in. pipes. Fig. 25 shows an assembled section of a complete mould and boxes fixed to the pit side, cramped up ready for pouring. Fig. 26 shows the box in the

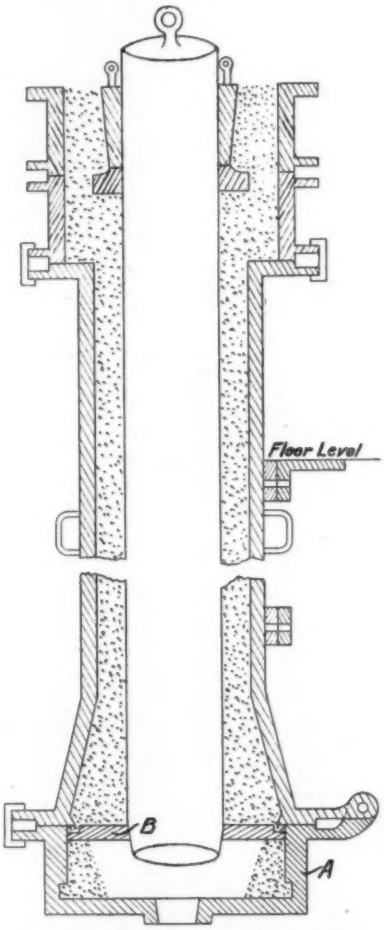


FIG. 27.—MOULD AFTER RAMMING OF BODY PATTERN.

same position before being rammed, the bottom-flange box being shown hanging down on its hinges. Fig. 27 shows the box rammed before the pattern is drawn. Fig. 28 is a sectional and plan view of the bottom flange box (A, Fig. 25); Fig. 29 is the ramming plate (B, Fig. 27); Figs. 30 and 31 the bottom-flange iron core box E and D; Fig. 32, these same put together ready for making the sand core forming the bottom flange; Fig. 33 the runner-cake core box; and Fig. 34 the core cake (F, Fig. 25), with runner gates. The other tackle has been described previously.

For 5-in. and 6-in. pipes the only difference in method is that the 5-in and 6-in. boxes are not fixed, hence the bottom-flange box is not hinged, but loose, and in that case when the mould is dried the long-length box is lifted with the crane and lowered on to the bottom flange box (G, Fig. 35), the sand core forming the flange having been previously put into the box. It is quite possible to fix the larger boxes if desired, providing the structure and fastenings are sufficiently strong. The difference is chiefly a matter of convenience, regarding room, quantity of tackle, etc., because once boxes are fixed it is an economical policy to leave them so, whether in use or not. The boxes for 3-in. or 4-in. diameter flange pipes do not occupy a great deal of space.

Fig. 35 shows the bottom-half section of the mould and boxes when making 5-in. and 6-in. pipes. It will be noticed that a bell box on the bottom of the long length is used in this case; it is rammed separately on the ramming plate before the long length is lowered on to it; this is necessary when the flanges require brackets cast on them, in order to keep the brackets in position and ram them regularly.

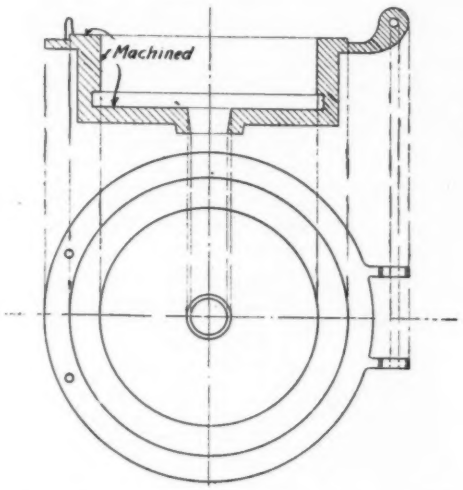


Fig. 28.—Bottom-flange Box (A, Fig. 27).

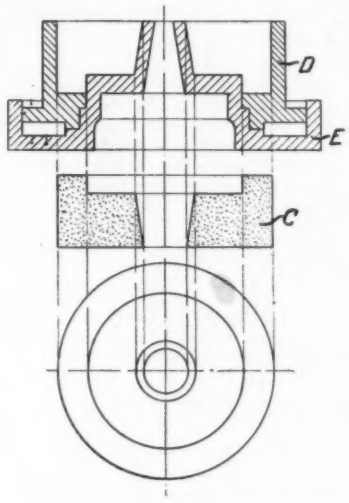


Fig. 32.—Iron Core Box Assembled, and Sand Core C.

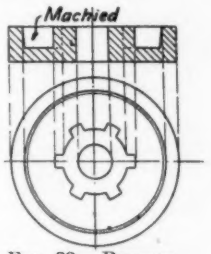


Fig. 33.—Runner Cake Core Box.

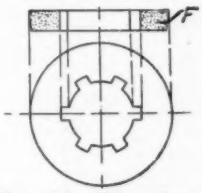


Fig. 34.—Core Cake, with Runner Gates (F, Fig. 25).

Fig. 36 shows, in section and plan the bottom-flange box, which is similar to the small one, excepting the absence of the hinges. Fig. 37 shows the ramming plate, with the body pattern in the seat.

A new Diesel engine manufactory, it appears, is to be laid down on the Clyde, the Fairfield Company and John Brown & Company being interested. With this new fac-tory there will be three works in Glasgow devoted solely to the building of Diesel engines. Work is being pushed ahead on the new factory of the North British Diesel Company, at Jordonvale. It will, however, be a year or eighteen months before the shops are ready to execute work.

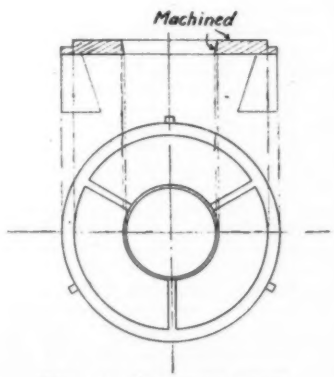


Fig. 29.—Ramming Plate (B, Fig. 27).

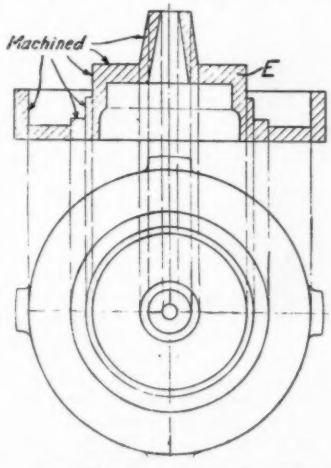


Fig. 30.—Part E of Core Box.

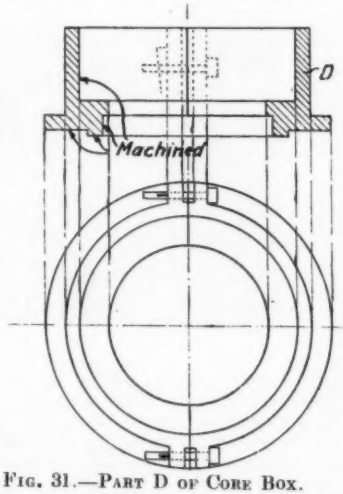


Fig. 31.—Part D of Core Box.

American Practice in Core Making.

Oil-sand cores as commonly used in American foundry practice were discussed in a Paper read by M. Henri Marquette Lane at the recent Congress of French foundrymen in Paris. According to the

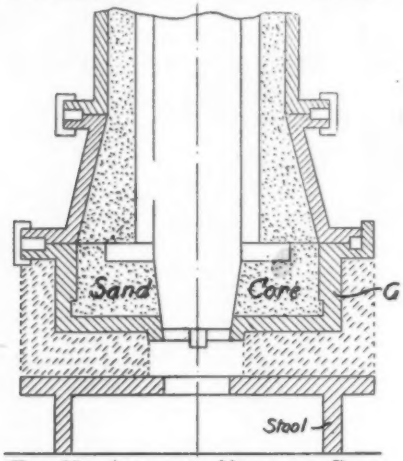


FIG. 35.—ASSEMBLED MOULD AND BOXES. FOR PIPES FROM 5 IN. TO 6 IN.

author, a considerable quantity of oil per week is used by hundreds of foundries in the United States, and some of them use as much as £20 worth per day. The leading principles in this practice are, briefly, as follows :—

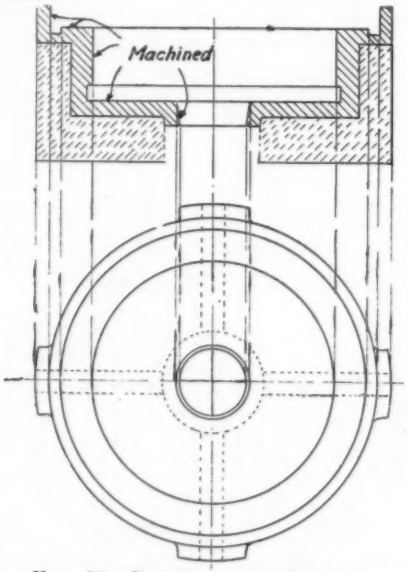


FIG. 36.—BOTTOM-FLANGE BOX FOR 5-IN. AND 6-IN. PIPES.

A distinction is made between binders used for green sand, and those for dry sand. The binders in common use are :—(1) Oils, comprising (*a*) siccatives such as linseed, cotton seeds, soya, fish and sperm oil, and (*b*) mixtures of siccative oils with resins dissolved in mineral oil; (2) binders prepared from pitch or resins, which hold the sand together when melted; (3) pastes prepared from flour or starch; and (4) binders soluble in water, such as stale beer, residues from the distillation of rum, molasses, glucose, and paper-pulp preparations.

Some binders have conflicting effects, while others may be used in combination. Establishments doing specialised work have standardised the composition and methods to be employed in the different branches of foundry work. Thus, oil-sand is almost exclusively used for the cores of tubular parts of up to 4 in. in diameter and for the water jackets of the cylinders of motor-car engines; also for radiators. The pitch base is used for the cores in large motors and for mechanical constructions in general. Aluminium foundries use cores prepared with resin, which soften when the metal is poured, thereby obviating cracking of the moulds. A mixture of clay and sawdust is employed for the cores of large castings; for draw-plate cores oil is mixed with flour pastes. All cores made from oil-sand can be dried

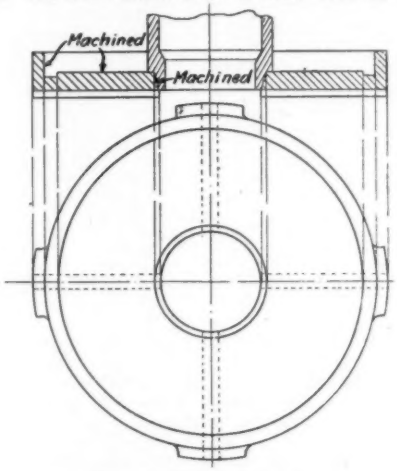


FIG. 37.—RAMMING PLATE WITH BODY PATTERN IN SEAT.

at a temperature of 250 deg. C., or a little higher. Those made with flour, starch or dextrine should not be subjected to more than 120 to 150 deg. The cores made with soluble binders can be dried at any temperature up to 205 deg.

For mechanical core making either rock-over or vibrator machines are generally employed, and during the last few years pneumatic devices have been used for replacing the sand in the core box and tamping it.

The greatest direct economies in foundry work have been realised through the replacement of hand-work by machines in the handling of materials, and when the work passes from one stage to the other. Some rules have been adopted for these operations; for example :—(1) In the handling of moistened sand do not expose the sand in thin layers to the action of the air, lest the water evaporate; (2) take all the supplies which the workman should use direct to his bench, and remove the cores as fast as they are made. For the latter purpose, the ordinary mechanical means (cranes, moving platforms or trucks) have not been found suitable; for, while the workmen who are farthest away from the drying ovens can always find a space where they can place their cores, those who are nearest to the ovens frequently find all the space occupied. In some foundries continuous roller tables, similar to those used in rolling mills have been installed, and the workmen push their work on to them of their own accord as soon as it is ready; (3) after drying, the cores should be placed in closed boxes, where they remain up to the moment they are to be used.

Ornamental Patterns.

By D. Gordon.

The methods adopted for the production of art castings are many and varied, ranging from the use of a chill, whereby the so-called "antique" bronzes are produced by hundreds, to the *ceri-perdu* or lost-wax process, by which only single castings can be made. To the average pattern-maker in wood, though these processes are of interest, as regards his own work (generally of an engineering character) they lack applicability. This in many of the methods adopted may be true, but it is equally true that when a pattern of an ornamental character is required it is, in its entirety, considered beyond his individual

FIG. 1.

scope. When a pattern of this type is required it is the usual practice for the pattern-maker to form up the necessary woodwork, then place it into the hands of a carver to execute the ornament, after which it is returned to the pattern-maker to alter the carver's work so that it will conform to the foundry's requirements. As will be readily admitted, these methods are not conducive to economical and quick output. Further, when the number of castings required is small, if relative values be considered between pattern-shop and foundry, their cost may prove to be exceptionally high. Another factor, perhaps the chief to be considered as it is a personal one, is

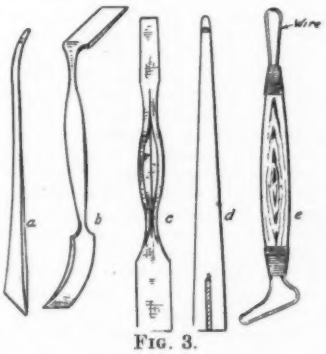


FIG. 3.

that when a certain product, ostensibly of a certain craft, is required and any ways or means are permissible in its production, if the work is not carried out solely by a member of that craft, then it shows a lack of that flexibility of labour so highly desirable, and withal so necessary for the full development and dignity of the craft.

In the present article a method for producing patterns of an ornamental character is described, and as modelling clay, or any similar substance, is used for the pattern's productions in plaster-of-Paris, it may seem, superficially, somewhat beyond the attributes of the pattern-maker in wood. This is in reality not so, it being chiefly a question of a change of material; and as the pattern-maker is already possessed of that appreciation of size, combined with an expert hand and eye training, the difficulties of using the material in question, and incidentally the tools, are in his case easily surmounted. The example that is taken for the purposes of this article is only chosen because it embodies very fully the main working principles involved in this class of work; it involves high- and low-relief treatment

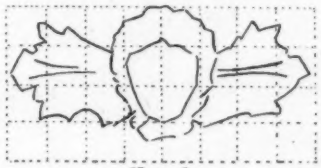


FIG. 2.

which in the pattern must give a clean lift from the mould without the aid of false cores or drawbacks. Also when working from a line drawing, as Fig. 1, a certain amount of liberty as regards the treatment of the ornament is allowable; the lines indicate what treatment is desired; but this is subjective to the effects produced by the play of light and shadow for obtaining ornament, pleasing or otherwise.

Upon a board a level plate of clay is struck up, this being done by means of two strips of wood attached to the board, their distance apart exceeding the size

FIG. 4.

of the ornament to the extent of about 2 in. The thickness of this clay plate is not arbitrary and should not be excessive, as it is only the foundation upon which the ornament is modelled. When this plate is made up and levelled with the upper surfaces of the wood strips, the main outline of the ornament is blocked out, the plate obviously being wide enough to allow this. As an aid to this the drawing, Fig. 1, is plotted out accurately into squares, similar sized squares being also produced upon the clay surface. The rough outline in relation to these squares is then an easy matter, and is done as shown in Fig. 2, no attempt being made at finished outline. Another

method, especially useful for small ornamental work, is to trace the design upon tracing paper with plotted lines, and transfer the same to the clay by going over the traced lines with a pencil point, the pressure being sufficient to mark the design. The plotted lines upon the base are necessary in either case, as they are the guides for working up the ornament relatively to them at the varying modelled reliefs. Clay is now brought roughly to the shape of the ornament, varying in thickness according to the detail, this thickness or relief being defined by the junction section of the leaf to the head A, Fig. 1, the highest portion of the leaf being indicated by the section B. These reliefs are applicable to both leaves, and for the centre piece the profile is given. Where portions of the ornament are applied over

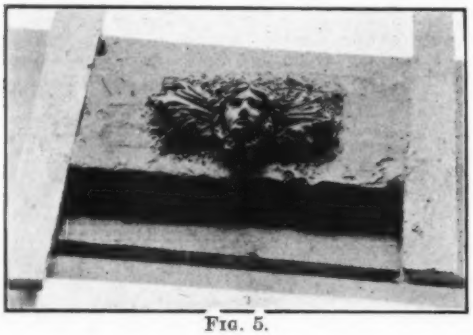


Fig. 5.

other portions these latter—as for example the hair over the forehead in the centre piece—should be placed on after the lower relief has been modelled.

The tools required for modelling are of various shapes and forms, and in Fig. 3 a few of the commoner kinds used are shown; but it may be taken that the shape and form of the tools are suggested by the ornament, and the tools can be quickly made out of any hard wood smoothly glass-papered. Tool *e*, Fig. 3, is used for roughing out and removing the heavier clay, *a*, *b*, *c*, *d* being modelling tools proper for finishing purposes; *b* and *c* are of steel, *c* at its extremities being pliable. With reference to tools, it should be borne in mind that the fingers are not the least important means for obtaining form, and

Fig. 6.

should be the chief, as they are the quickest, for at least the roughing-out of the work. When the work has been roughly modelled up with the tools—the use of the fingers in the example shown is obviously limited, owing to its size—as in Fig. 4, in which the working of the tool is shown accentuated as much as possible, a little more definition and smoothness is obtained, the calipers, rule, and the plotted lines being the means for obtaining proportion and size.

In small work no attempt should be made to obtain definite finish, as it is better to do this in the resultant pattern, of either plaster or metal; attempting it at this stage is not only a tedious job but also a waste of time. For larger work it is desirable to obtain as much finish in the clay stage as possible, since by so doing the resultant pattern work in such cases is reduced—a fact which will be more readily appreciated when it is mentioned that sharpness combined with clearness is obtained in the pattern proper by means of the graver or chaser.

Fig. 5 shows the model prepared for casting up, this being done by preparing or obtaining in plaster-of-Paris a mould of the model. To do this, plaster mixed to the consistency of cream is poured over the clay and banked over so that when the plaster has "set" a sufficient thickness is obtained to give strength and rigidity for the next process, Fig. 6. When the plaster has "set" a piece of thin wire is inserted under the one end of the clay base and drawn along the entire length of the base, thus separating it from the board. In some instances this is necessary previous to casting over the plaster. The "cast" is now lifted away from the board and the modelled-up clay removed, which then leaves in the plaster-of-Paris the impression of the clay model. The plaster mould is thoroughly cleansed with water so that every portion is clean and free from clay, and is afterwards thoroughly dried. The surfaces of the mould are treated according to the material which is to be used for the pattern; if a plaster pattern is required these surfaces are coated with any light oil, care being taken that only a fine film is given, as any excess is liable to form blowholes of an unsightly

Fig. 7.

character, which entails further labour to rectify. This oil acts as a parting between the plaster mould and the plaster which is cast into it to form the pattern. When metal—usually a white metal—is used, the surfaces are dusted over with plumbago, this being well brushed down and all excess removed. Into the plaster mould the material desired is poured and, if entire solidity is not required, the mould is rotated and the remaining liquid material poured out, thus leaving an indefinite thickness of material covering the mould surfaces. This may be repeated until the desired thickness is obtained, but a definite equal thickness throughout is by this process not obtainable.

After the cast has thoroughly solidified, the plaster mould is broken away, and in the event of plaster being used for the pattern, care has to be exercised so that the ornament is not damaged by the tool used for removal purposes. A method that is often adopted to prevent accidents of this description is to form a thin coating of *coloured* plaster over the clay model, backing this up with the ordinary white plaster, as shown in Fig. 6 *a*, this coloured plaster indicating the proximity of the ornament during the breaking up of the mould.

The pattern produced, Fig. 7, is now prepared for moulding purposes, and the amount of work involved in this direction depends entirely upon the state of the previously-made model.

Manufacture of Cast-Iron Cylinders.

There is no kind of castings turned out in the ironfoundry which causes greater trouble than cylinders. Success with these castings varies greatly in different foundries. In some cases the losses are constant, and represent up to 50 per cent. of the cylinders poured, while sometimes the work goes fairly smoothly, and 95 per cent. of the castings may pass inspection. But it does not follow that the quality of the castings accepted by the engineer in the fitting-shop where 50 per cent. are rejected is any worse than in the shop where 95 per cent. are passed as good; in fact, the very opposite may be the case. Possibly that foreman who is putting 50 per cent. of his cylinders on to the scrap-heap may be doing more valuable work for his company than the man who is only losing 5 per cent. If there is being used in a foundry attached to a shop making steam or other engines, a soft or unsuitable iron mixture for the cylinders—that is to say, a material which is so comparatively easy to handle and control in the melting and pouring operations as to greatly reduce the chances of waster castings—it is possible that the inferior cylinders turned out may be bringing the firm into disgrace amongst their customers. On the other hand the foreman who is struggling with a hard, suitable iron mixture and its accompanying difficulties may be delivering to the workshop his 50 per cent. of cylinders of such a quality as to bring special credit to his firm, which may fructify in the shape of repeat orders.

The writer has seen cylinders returned to engineering firms after so little as three months use worn away in the bore by two or three millimetres and either requiring to be re-bored or entirely replaced; and he has also seen cylinders which have been working ten years in an engine without having to be removed, and which have not worn away at all. The mischief of soft cylinders is great. Increase in internal diameter may mean serious steam leakage, or it may even mean sufficient disturbance in the alignment of the moving parts as to cause injury to the engine or even breakdown. Cylinders are large castings of comparatively thin section; there are no, or in any case few, solid portions. This, of course, explains at once why a cylinder is a comparatively difficult casting; it is impossible to use the usual soft foundry mixture which is specially suitable for thin castings from the moulders point of view; and also it has no heavy sections on which gates may be so advantageously placed. Cylinders have to be cast with a strong and comparatively pure iron which has high liquid shrinkage, and which is not as a rule tapped from the cupola at greatly above its freezing-point. The problem of pouring a thin and often complicated casting with that kind of iron, where there are no or few heavy sections on which to place gates or feeding-heads and much core surface, and often awkward core projections, is the problem of cylinder casting.

It is not proposed here to deal with each of the different varieties of cylinders individually and describe all the different moulding and casting methods, but an attempt will be made to lay down a few general principles which can be applied to this class of casting under all circumstances, and the observance of which may help the moulder to achieve success. The points of special importance may be classified very roughly under three headings as follows:—(1) The iron mixture; (2) the mould and core materials and the venting; (3) gating, rising and feeding.

With regard to the iron used, the requirements are two-fold. The metal in the cylinder must be hard, dense, and comparatively strong (*i.e.* resistant to bursting stress), and the same metal when melted must be very fluid so as to fill all parts of the mould perfectly. These two requirements are somewhat conflicting. To obtain the necessary fluidity by using a high-silicon, high-carbon mixture is out of the question, because such a mixture will be comparatively soft when solidified, and will be porous owing to excess of free carbon. On the other hand a low-silicon mixture, also low in total-carbon and fairly low in phosphorous, *i.e.*, a strong iron, will, if treated in the ordinary way, be lacking in fluidity. It is therefore necessary to compromise and find out in what way the necessary fluidity can be secured in the iron without too great a sacrifice in density and strength. The writer's experience is that the best means are as follows: Take a low-silicon and low-carbon mixture, but raise the phosphorus as high as it can safely go without seriously weakening the metal, and pour the iron at the highest possible temperature. It may be added that manganese should be present in rather larger quantities than in mixtures for ordinary machine work.

Sulphur has not yet been discussed, but this must be allowed to reach a normal figure in relation with the other elements. In a mixture consisting mostly of coke-smelted pig-iron, the sulphur will vary in a certain ratio inversely with the silicon. If much charcoal iron be used the sulphur will be proportionately lower. The writer's opinion is that the sulphur question is not vital, provided it is known that neither the fuel nor the scrap is exceptionally high in sulphur, and that the brands of pig-iron used are holding a normal sulphur in relation to their silicon.

This applies only to high-grade brands of pig-iron, such as are to be had from many furnaces. The control of sulphur in the smelting of common brands of foundry pig-iron is not so careful, and the sulphur is liable to be very high in the lower and harder grades. All such irons are fundamentally unsuited for cylinder work. The following table shows approximately what should be expected as regards sulphur and silicon in special coke cylinder pig-irons. The total carbon is also given:—

Phosphoric.

Silicon Per cent.	Sulphur. Per cent.	Phosphorus. Per cent.	Total Carbon. Per cent
2.5	0.03	0.8 to 1.25	3.40
2.0	0.04	0.8 to 1.25	3.40
1.5	0.06	0.8 to 1.25	3.20
1.25	0.09	0.8 to 1.25	3.00
1.00	0.10	0.8 to 1.25	3.00

Non-Phosphoric or Strong.

Silicon. Per cent.	Sulphur. Per cent.	Phosphorus. Per cent.	Total Carbon. Per cent.
2.5	0.02	0.05	3.75
2.0	0.03	—	3.75
1.5	0.06	—	3.5
1.25	0.10	—	3.5
1.0	0.12	—	3.5

With very high sulphur the shrinkage may be so high as to cause fractures in the iron, but beyond that, little is proved scientifically as to the direct evil influence of sulphur in iron castings, save that if excessively high it will make iron white and brittle. Sulphur is only dangerous in fairly high

quantities in cylinder metal in the absence of a proper percentage of manganese. It has a greater affinity for manganese than for iron, and in the form of manganese-sulphide a great deal will come up through the iron in the mould and be caught in the risers or flow-offs. If, however, the sulphur is high and the mixture poor in manganese, more sulphur will combine with the iron as iron-sulphide, with mischievous effects. Such iron-sulphide decomposes readily, and gives off much gas, which may blow the metal or make it spongy. To complete the specification previously given, then, it may be added that sulphur should be according to the silicon and safely to 0.125, along with the right quantity of manganese.

It should be understood that no specification as regards chemical composition can apply equally well to all sizes and thicknesses of cylinders. A mixture having silicon of 1.25 and a sulphur of 0.12 is suitable for cylinders with a wall-thickness of 25 mm. to 30 mm.

As regards phosphorus in relation to the strength of the cylinder, there is no specific data to be had with regard to the effect of different percentages of this element on the tensile strength of cast iron, and the statements generally made do not rest on any scientific base. All that is said is that phosphorus tends to make iron brittle. This may be granted as a generalisation, but it is not possible to lay down definite percentages of phosphorus which will exercise a definite effect. Authorities on cast iron all differ on the subject. The writer has seen the statement made by an expert that in hydraulic cylinders, phosphorus may safely be as high as 1 per cent., and another statement by another expert that it should not go above 0.2. The writer's own repeated experience has been, in connection with cylinders, that phosphorus up to 0.8 is not incompatible with very high tensile strength. The last actual tests made by the writer on cylinder metal gave the following results:—(*a*) Ten tensile tests of a cylinder mixture holding 0.636 phosphorus:—mean, 16.4 tons per sq. in.; maximum, 18.39 tons; minimum, 15.14 tons. (*b*) Seven tensile tests of a cylinder mixture holding 0.777 phosphorus:—mean, 15.943 tons per sq. in.; maximum, 17.35 tons; minimum, 14.36 tons.

The analysis of this iron, which was of exceptional quality, was:—(*a*) G.C. 2.5, C.C. 0.812, Si. 0.98, S. 0.132, P. 0.636, Mn. 0.70; (*b*) G.C. 2.39, C.C. 0.922, Si. 0.95, S. 0.125, P. 0.777, Mn. 0.83.

This question of the tensile strength of cylinder metal must be examined in conjunction with the methods employed by engineers in designing cylinders and calculating their thickness. The formula now generally employed places very little responsibility on the iron and the custom is to allow a very ample margin of thickness over that actually necessary to stand the stress, and to calculate for iron having a low, not a high tensile strength; so that as a rule any cylinder cast nowadays is amply strong enough for the work it has to do. Hence the importance of high tensile strength and of the phosphorus content in the metal is not great. The writer is anxious, however, not to minimise the necessity of high tensile strength in cylinders, if not with a view to present requirements at any rate with a view to the future. The rapid development of the internal combustion oil-engine will have an important bearing on this matter, and will in time throw greater responsibility on the foundry. The difficulty in the way of adapting the marine oil-engine to large ships lies in the comparatively small amount of power developed in proportion to the size of the cylinder. At present, increased power is got by multiplying small cylinders, but it is certain that a necessary stage of development will be an increase in the amount of power developed in each cylinder. With this must come the demand for greatly increased tensile strength and reliability in cylinder metal.

To sum up regarding phosphorus, it must be said that it performs useful functions, which more than counterbalance any possible reduction it may cause in the strength of the metal. It prolongs that semi-fluid condition in molten iron during which the operations of feeding exercise such a beneficial effect, and the higher the phosphorus the greater the advantage derived from the pressure obtained by sinking or feeding-heads. It increases the expansion of cast iron, which takes place at different stages during cooling, and thus tends to counteract the excessive shrinkage which occurs with low-silicon, low-carbon iron, and, *ipso facto*, it helps to make solid castings. The analyses given above are excellent for cylinder iron, but they may still be improved upon. This iron was very hard; not too hard for cylinders, but hard enough to cause a grumble in the fitting-shop. A still lower carbon could be got by a careful selection of the raw material, and the phosphorus might with advantage be slightly higher. The following might be taken as an ideal composition for cylinders having a wall-thickness of 20 to 30 millimetres:—Total carbon 3.00 per cent., silicon 1.25 per cent., sulphur 0.10 per cent., phosphorus 0.80 per cent., manganese 1.0 per cent. For thinner or thicker sections only the silicon should be altered, which will, however, automatically after the sulphur. The reasons for pouring the iron hot are many, and only one or two of the principal can be mentioned here. First, there is the advantage of increased fluidity. Secondly, strong, low-silicon irons are not as a rule raised above their freezing-point in the cupola to the same extent as soft iron, and hence their range of fluidity is smaller. This accounts in many cases for the cavities, shrink-spots, and spongy places in castings made with hard iron, because the rapid freezing of the metal does not give time enough for the shrinkage to be adequately supplied through the gates or risers. Thirdly, if the metal has been tapped dull, it has very likely been spoiled in the cupola beyond all cure, and if it has been tapped hot, and allowed to get cool in the ladle, impurities will have been separating out of the metal and forming slag. The cooler the iron the more rapidly it oxidises, and it is the oxidisation of the silicon and other elements in iron which makes slag. If the iron be poured into the mould extremely hot, it will freeze into a sound casting without forming an excess of slag, whereas if dull, the slag will form too freely, and may either get trapped in the iron or stick fast at angles or underneath projecting parts of the mould, and spoil the casting.

Considering next the mould, it seems hardly necessary to mention points so often discussed in foundry papers, regarding the construction of the pattern. Before a foreman begins to mould a cylinder he should be satisfied that the pattern contains no faults from the moulder's point of view which could be altered without affecting the work which the cylinder has to do. All angles should be filleted, and any lug or connecting part or steam-chest or valve attachment which is unnecessarily heavy or light should be altered, with the object of doing away as far as possible with sudden variations in thickness. It should be taken as an axiom that a drawing-office will never regard a pattern from the moulder's point of view, and that there are always details in patterns which can be altered in accordance with the principles of iron-founding without in any way impairing the function of the cylinder.

For moulding, the ordinary sand mixture will probably do, if the subsequent drying process be properly carried out. Special attention, however, should be

paid to the gates and runners. Where hot iron is to be used, the ordinary foundry sand mixture should be reinforced by some harder and more refractory material at those points where the inflowing iron will impinge.

The facing material for cylinder moulds poured with hot iron also demands special attention, and no regular good result can be expected unless careful thought is given to this branch of the work. Coal-dust of the finest quality, that is to say, a dust from a pure high-grade coal of a high-carbon content, should be used for the facing mixture. Bad coal will not burn out freely and the air and gas will not escape through the mould but go up through the metal and blow the casting. The coal dust must burn out freely and quickly, otherwise it will not protect the mould from fusion, which must result in a faulty casting. No amount of previous venting will prevent this. Care must be taken that an excess of coal dust is not used, as in this case the casting may be blown through excess of gas from the coal itself. Dry-sand cylinder moulds should be thoroughly well vented, and they should be vented in the cope as well as in the drag part. The vent wires should not be pushed in haphazard by the moulder without accurate knowledge of how far and where they are going. The venting should be done carefully, and the vents evenly distributed and taken to within ¼ in. of the pattern.

The construction of the cores is the most important point in cylinder work. Cores should be made of a special sand mixture consisting of a much higher percentage of new sand than is used for the mould, and where the cores are thin and delicate or exposed to much pressure from the metal, all new sand of a very refractory nature should be used. The writer is of the opinion that a great many of the special core binders that are used in building cores are a mistake. One or two oil binders on the market are excellent, but others are unsatisfactory, as their bonding power is insufficient when a sharp sand is used and the core has to be reinforced with other foreign materials, the behaviour of which, when the iron strikes them, is very uncertain. If an oil binder can be found which will make a hard, strong core with a pure, fine silica sand without the use of any other medium, a satisfactory result may be expected. A core made in this way should naturally be absolutely porous, and some of them bake as hard as stone in the oven, and have a considerable transverse strength. In making up cores with sharp sand and a simple oil bond, a little moistening is required. This should be supplied by means of kerosene or water, either used extremely sparingly. It must, of course, be remembered that no mixture will do which cannot be fairly easily broken up and removed after casting. Good cylinder cores should fall from the casting in a fine powder when the casting is struck or shaken.

Having decided on the materials for the iron and the moulds, the next point is the gating of the casting. There is so much difference of opinion on this matter that it will perhaps be best to lay down such basic principles as can be accepted on all hands, and see then to what course of action such principles lead. Incontestible principles seem to be:—(1) Fill the mould as quickly as possible; (2) as nearly as possible allow the iron to cool in the mould from the bottom upwards; (3) maintain as high a pressure as possible in the mould as long as the iron remains fluid.

The whole system of gating and feeding should be based on these principles. They point inevitably to the conclusion that cylindrical castings should be cast vertically and gated from the top. When pouring a mould from the top there is practically no resistance to the inflow of the metal, and the mould can be filled more quickly. With bottom gates the inflowing iron is working all the time against the resistance in the mould, and the rapid cooling of the iron already in the mould. The cooling metal rises to the top, and the hot metal enters at the bottom. Should there be any air or gas or foreign substance in the lower part of the mould it will be much more difficult for them to escape in the natural direction, *i.e.*, upwards, through the already partly chilled metal above. Often cylinders are seen spoiled by trapped air or gas in the cope part. The pressure is clearly greater from the top than from the bottom because the velocity of inflow is accelerated by gravity from a top gate and retarded by gravity in a bottom gate, and the pressure will be greater in a vertically- than a horizontally-poured cylinder. With large cylinders there can be no question which is the best method. Metal slowly rising up in the mould of a heavy section casting is forming scum and slag, whilst it cools, and unless this slag is disturbed by the continued pouring, it may stick to the sides and possibibly get trapped in the mould. If the iron is entering at a good velocity from the top the slag will be broken up, and it will be kept in motion by the continued deposit of fresh hot iron on the surface of the rising metal, and pass in due course out through the gates.

Against this we have the fact that the design of cylinders is often such that it is difficult to find a suitable place on the upper surface to place top gates. It must, however, always be possible to run a cylinder from the top, and if the conveniently available surface is small it is still best to utilise it and to make up for lack of area by having a good number of small gates. It may, however, in this case be necessary to take special precautions to keep these gates open until all liquid shrinkage in the casting has ceased. Heavy sections at the top of the casting are clearly the best place to put gates, and the old-fashioned system of putting a tapered sinking-head on the flanges of cylinders is certainly the surest way to guarantee a sound casting. The use and expense of a sinking head may, however, be avoided by the use of an absolutely suitable iron mixture coupled with proper attention to the construction of pouring-basins and the supply of fresh hot metal in the gates until liquid shrinkage has entirely ceased. Jacketed cylinders may be very advantageously cast with the jacket end upwards; as the advantage of having the jacket core open at the top, and thus allowing a free, direct vent, outweighs as a rule all other considerations.

There are, no doubt, certain types of cylinders which need special consideration on their own merits, especially jacketed cylinders and multiple and composite cylinders of various kinds. But the writer in this article has only attempted to point out certain fundamental rules which can be applied more or less in all cases, and his final word here is: Have certain fixed principles and stick to them through thick and thin. Continual changing in materials and working principles will never lead to permanent success with cylinder castings. If a moulder has an idea and can give cogent and logical reasons for it, it is better for him to stick to it until it is absolutely confounded to his own satisfaction than to drop it the first time he makes a waster. Jumping from one method to another without knowing specificially why, is merely groping about in the dark. The uncertainty of the result with cylinder castings, even in the best of foundries, is something which makes us rather bear those ills we have than fly to others that we know not of.

Titanium in Steel Making.

The great progress made in the use of titanium as an alloy in the manufacture of steel, together with a number of practical suggestions as to the best methods of employing it in steel-making practice, are embodied in an interesting article contributed by Mr. E. F. Lake, to a recent issue of "Metallurgical and Chemical Engineering." He remarks that no method was found for reducing the titaniferous ore and extracting the pure titanium until the electric furnace, with its high temperatures, was made a practical success. This was due to its comparatively high melting point of 2,300 deg. C. Titanium also has a specific gravity of 5.174, which is considerably lower than that of iron at 7.2. The many tests made conclusively proved that the best results were obtained from ferro-titanium that contained from 10 to 15 per cent. of titanic acid. When 20 per cent. was present it would not dissolve thoroughly at the usual working temperature of an iron or steel bath, and higher percentages caused a segregation that produced hard spots in the metal. The 10 to 15 per cent. ferro-titanium generally contains about 6 per cent. of carbon and 5 per cent. of all other impurities. As one-half of 1 per cent. of titanium is all that is usually added to the molten steel, the percentage of carbon and other impurities in the finished product can easily be controlled.

The great affinity of titanium for both oxygen and nitrogen makes it of special interest to the steel-maker and also to the steel user. It has been proved beyond doubt that these two latter elements lower the static strengths and dynamic properties of steel, the wearing qualities and resistance to friction, and increase its tendency to corrode. Removing the gases from steels by the addition of titanium, directly increases the cohesive force in the mass by removing the microscopic, or even larger, bubbles which they form. As both oxygen and nitrogen are gaseous by nature it is difficult to analyse steels for these elements, but satisfactory results are now being obtained. In one lot of 24 specimens the oxygen content was found to range from 0.021 to 0.046 per cent. These may seem small enough to be ignored, but it is the combinations the oxygen will form, and not alone the percentage of this element, that must be considered when its effect on the steel is judged. As an example of this, we talk about the injurious effects of 0.05 per cent. of sulphur, when it is really the 0.13 per cent. of manganese sulphide that alters the quality of steel. Oxygen has only one-half of the atomic weight of sulphur and, owing to its being capable of forming many more compounds, it exerts a much greater influence. Thus 0.05 per cent. of oxygen may mean that 0.22 per cent. of ferrous oxide is present and this is a large enough percentage to have an important influence on the metal. When oxygen comes in contact with steel, either in a moist or heated atmosphere, oxides are formed. These oxides are always found in steels that develop blisters when being pickled. Bessemer steels contain the largest amount, with open-hearth steel second; crucible steels next, and electric-furnace steels the most free from oxides. The blisters are probably formed by the reduction of the oxides by the nascent hydrogen evolved during the pickling operation. When titanium is added in the proper manner to the bath of molten steel it forms, with the oxygen, a titanium-oxide. This, being lighter than steel, floats to the top of the bath, enters the slag and is removed therewith. Thus no injurious compounds are formed with the oxygen.

That the reduction of oxides is brought about by the nascent hydrogen may be easily demonstrated That oxygen increases the tendency of steels to corrode is shown by the fact that polished specimens, containing oxides, begin to rust much sooner than those that are practically free from them. Welds are never perfect, as we are not able to squeeze all of the oxide out of the joint. It there forms into small globules that interrupt the cohesive force which binds the molecules together. These, as well as other instances of the injurious compounds that are formed in steel by oxygen, show the necessity of removing as much of this element from steel as possible. While silicon, manganese, and other of the more common elements have been used for a long time for this purpose by steel makers, they still leave a percentage in the metal that is large enough to become an important factor. Quite recently therefore, aluminium, vanadium, titanium, zirconium, etc., have been brought into use to remove the smaller percentage that is left by the ordinary steel-making methods, and very good results have been obtained with all of them. Titanium does this work as effectively as any of the foregoing, and is destined to be more universally used, as it is easily made to perform its mission and is much cheaper in cost. In the manufacture of steel rails with the Bessemer process it only adds about 5s. per ton to their cost. In higher grades of steel the additional cost is seldom up to 8s. 6d. per ton.

That nitrogen is injurious to steel is shown by the fact that each increase causes the elongation to rapidly diminish and reduce its ductility. Generally speaking, steels have lost their elasticity and their elongation and contraction have become nil when a nitrogen content of between 0.030 per cent. and 0.035 per cent. is in the steel. An 0.5 per cent. carbon steel might not lose its ductility, however, until from 0.04 to 0.05 per cent. of nitrogen was reached, and in the softer steels from 0.05 to 0.065 per cent. might be present. In open-hearth steels the nitrogen content is usually between 0.020 and 0.025 per cent.: in Bessemer steels from 0.018 to 0.062 per cent.; and in crucible steels from 0.010 to 0.015 per cent. Thus at least 0.012 per cent. of nitrogen must generally be reckoned with. Steels made in the resistance electric furnace are practically free from nitrogen and hence are an exception to the above rule. Those, however, that are made in the arc electric furnace, in the presence of basic slags, are liable to contain enough nitrogen to be injurious. Nitrogen will not combine with steel by heating the two together, but in an atmosphere of ammonia they will unite. If the coking of the fuel has not entirely removed the nitrogen in the coal, ammonia is doubtless introduced into the blast furnace in that way. When nitrogen has once entered the pig-iron in the blast furnace it cannot be removed by any subsequent reheating and hence is found in the finished steel.

Titanium, however, has a great affinity for nitrogen and when properly added to a steel bath it forms with it stable nitride which is lighter than the molten steel and rises to the slag. This nitride shows as tiny red crystals under the microscope. The very energetic reaction of titanium and nitrogen takes place at a temperature of about 800 deg. C. Combinations that are of no value are formed, however, if the air is carelessly shut off during this reaction and thus the good effects of their union will be greatly lessened, if not completely nullified. Titanium is about the only element that readily com-

bines with the nitrogen in steel and carries it away to the slag. Titanium should only be used for removing the last traces of these gases, after the ferro-silicon and manganese have done their work, and hence should be added in the ladle.

The ferro-titanium comes well broken and ready for use. Being lighter than iron, it will not sink and disseminate when added near the top. Therefore, it should be put in, a shovelful at a time, while the molten metal is flowing into the ladle. If the stream is made to strike the ladle at one side a swirling and churning action is given the molten mass in the ladle and any ferro-titanium that might be floating on the surface will be engulfed and disseminated through the mass, where it is quickly dissolved and starts on its mission. It should never be preheated, as this sometimes prevents a complete reaction in the steel. Some begin by adding 1 per cent. of titanium and gradually reducing this until the beneficial results obtained begin to diminish from the maximum point obtained.

The steel in the ladle should never be above the normal temperature for good untreated steel, as the reaction set up by the titanium causes the temperature to rise to a certain extent. After adding the titanium, the ladle should be allowed to stand from five to thirteen minutes so that the impurities and slag, released by this reaction, will have time to rise to the top of the ladle and not segregate in the steel. It is very difficult to make steel-makers realise this, as no other material they use acts in this manner. Virtually there is no segregation in steel ingots containing titanium. The gases liberated from the steel as it cools and hardens, rise in vertical streams and carry up the specifically lightest elements. Selective crystallisation entraps them as the metal cools and the top of the ingot will show the most segregation. If these gases are made to combine with an element like titanium, which carries them into the slag, the steel will harden with practically no occlusion of gases. If there is any titanium in the steel after the occluded gases have been removed, it has a tendency to attack the sulphur and phosphorus and either counteract their injurious effects or remove them. The sulphur is reacted on and carried away to the slag in the form of a sulphide or sulpho-cyanide of titanium. Special means have made the phosphorus pass into a slag as phosphate of titanium. Thus the mission of titanium does not seem completed after the oxides and nitrides have been removed.

It was thought that the electric-furnace steels would be made so free from gases of all kind that they would not need the service of any purifying element. This, however, has been proven erroneous, for titanium is now used for the removal of the last of the gases in electric-furnace steels. An exception must be made in the resistance electric furnace, however, as steels made in that type are practically free from oxygen and nitrogen.

Some Notable Castings.

In connection with the new transatlantic liners of the Imperator class, two of which are in course of construction at the shipbuilding yard of Messrs. Blohm & Voss, at Hamburg, some very large castings have been necessary for the casings of the steam turbines which drive the four propellers. The accompanying illustrations, for which we are indebted to the "Zeitschrift des Vereines Deutsches Ingenieure," show some of the castings in question. The heaviest was that of the casing for the low-pressure turbines, the rear top part of which is depicted in Fig. 1; it has a maximum diameter of 18 ft. 6 in., the width and depth being about 6 ft. 6 in., while the weight is 38 tons. Figs. 2 and 3 show respectively the casing for the high-pressure reversing turbine and that

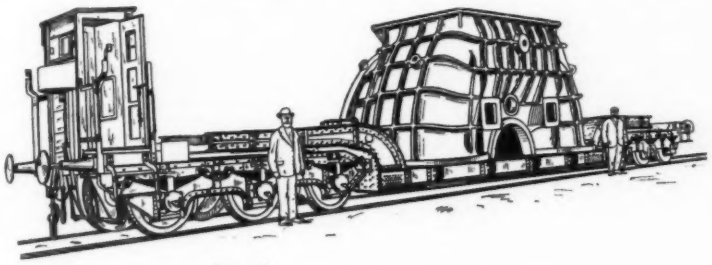


Fig. 1.

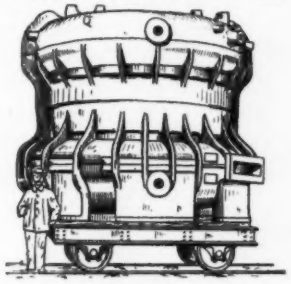


Fig. 2.

for a medium-pressure turbine. Each of the two steamers has eight turbines; one of the latter is equipped with cast-steel casings, and the remaining seven have casings of grey cast iron, consisting of no less than 30 castings, the total weight with the bearing journals being about 1,000 tons. The whole of the castings were supplied by Messrs. Ehrhardt

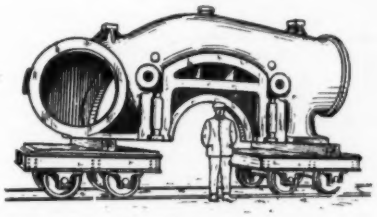


Fig. 3.

& Sehmer, of the Schiefmühle Maschinenfabrik, Saarbrücken, Germany, those for the first steamer being turned out in twelve months and those for the second in ten months. Considerable difficulty was experienced in obtaining railway trucks to transport the castings to Hamburg, no suitable wagon being available on the German railways. Much delay was thereby caused, as it was found necessary to place an order with the Fuchs Wagon Works, in Heidelburg, for the construction of the special truck shown in Fig. 1; as will be seen, it comprises two six-wheel bogies; the total wheel base is 52 ft. 6 in., while the loading platform is only just over 2 ft. above the ground.

A Brief Note on Foundry Estimating.

By "Erimus."

On receipt of an enquiry the weight or weights of the goods enquired for should be carefully calculated. This is the first essential, whether you have to quote a price per ton or a lump-sum price. There are several tables to be had giving weights of pipes, balls, cylindrical solids, plates, etc., which are of great use to an estimater, but which need not be ennumerated; failing any of these, the weights of castings are easily worked out if one has a couple of lists handy, say:—(*a*) Table of circumferences and areas of circles; (*b*) table of weights of cubic inches. Areas of squares and rectangles are easily worked out and need not be tabulated for estimating purposes.

It is necessary to have an estimate form to fill in, and if properly dealt with there is little fear of any item of expenditure being overlooked. Fig. 1 is offered as a useful form for either jobbing or special foundry work. This can be used in book form or on the loose-leaf or card system. Its utility is twofold, as both the estimated cost and actual cost are recorded, and in case of a repetition order being sent the figures are available for immediate use.

Always consult the foremen of the several departments as to estimated cost of skilled labour, as being practical men and knowing the appliances they have at their disposal, they are better able to state the time it will take to produce.

Ruling for Estimate Form and Cost Sheet.

Date.	Name of Firm.	Estimated Weight. Tons.	cwts.	qrs.	lbs.	Actual Weight. Tons.	cwts.	qrs.	lbs.
	Total weight								

		Foremen's Estimate.	Estimated cost per ton.			Actual cost per ton.		
1	Patterns Wages .. .. Timber, screws, etc.							
2	Moulding and Coremaking							
3	Tackle (if special for the job)							
4	Labour, Melting, Cleaning, etc.							
5	Cleveland Iron and Waste							
6	Hematite or Special Mixture and Waste							
7	Establishment and General Charges							
8	Carriage or Carting							
9	Machining or Fitting							
10	Fitting Shop Expenses							
11	Smithwork							
12	Smithy Expenses							
13	Painting and Paint							
14	Tests							
	Total Cost of Production							
	Profit							
	Price quoted per ton							
	Price quoted, lump sum							

Time.....days.

Patterns are sometimes provided by the buyer, and cost of preparation will not then be included in the estimate. If they are to be provided, the foreman will give his estimated cost of wages and the amount of material he will use, or state the cost of altering existing patterns to suit the work enquired for.

Moulding and core-making being skilled labour, are readily accounted by the chargeman, who will, of course, take into consideration the boxes he will use and perhaps the man he will employ. Unfortunately, all moulders, although they get the same rate

of pay, are not capable of doing the same amount of work, hence the necessity of the foreman deciding, when estimating, to which man he will give the work.

It is not always advisable to charge the preparation of tackle to the job, unless it has to be specially prepared and is of no use afterwards. For convenience the general labour, melting, cleaning, and miscellaneous men can be grouped together under the heading of labour charges, and from previous abstracts the cost may be easily arrived at. For general work the average cost may be taken over a period of a few months, but the estimater must discriminate between plain green-sand work and complicated dry-sand or loam work, and base his estimate according to the nature of the work to be undertaken. An estimater and cost clerk should have frequent access to the work shops for observations.

The market price of pig-iron, plus 5 or 7½ per cent. for waste, is a safe figure for ordinary or special mixtures in a jobbing foundry, but a much lower figure for waste can be taken in a works where the cupola is working continually all day long, such as chain and pipe foundries.

Having records of establishment and general charges, there need not be a great deal of trouble in judging the amount to be expended under this heading. Care must, of course, be taken to discriminate between green-sand, dry-sand and loam work, according to the amount of time to be spent on the job, and coke, stores, etc., used for same. Under this heading cupola coke, fuel, rough coke (for stoves), stores, rents, rates, taxes, gas, water, insurance, stationery and office expenses and salaries may be included. The cost of all these can be ascertained under all the sub-headings named by abstracting the purchases.

Local traffic can usually be carted cheaper than railway companies can deal with it, owing to the latter insisting on 4-ton loads for trucks as a minimum load. It is advisable to have a railway rate book, and this can, in time, be compiled from carriage accounts if one of the published ones is not available.

Heat Balance of the Open-Hearth Furnace.*

By Sidney Cornell.

The modern blast furnace, as operated to-day, is run with due consideration for known chemical and metallurgical laws, but this is not so much the case with the open-hearth furnace. The advantage of a change in this direction can be appreciated, and the time has come for betterment of the conditions as existing in open-hearth practice from a metallurgical standpoint.

The data from which this test was figured were obtained at the Duquesne Works of the Carnegie Steel Company. The open-hearth furnaces tested were two 60-ton furnaces, together with their four Hughes mechanically-operated gas producers. It was necessary to test two furnaces owing to the fact that the gas flues from the four producers are not separated; hence the gases from four producers feed two open-hearth furnaces. The hearths of the furnaces tested were 32 ft. by 14 ft. 9 in., and the Hughes producers were of the standard design for that type, and capable of gasifying 25 lbs. of coal per square foot of grate area per hour.

The test covered an entire week, starting when the steam was turned on the producers on the Saturday of one week, and terminating when the steam was turned off the producers on the Saturday of the following week, thus covering a period of 161 hours and 32 minutes, and during which time 12 heats were made in one furnace and 11 heats were made in the other, with a total tonnage from the two furnaces of 1,615 tons for the week. The following table gives a summary of the heat distribution and is the heat balance :—

Heat Balance. Heat Distribution per Ton of Ingots.

	B.T.U.	Per cent.
Heat in materials charged to producers	7,087,795	—
Heat in producer gas in downtake	6,733,050	—
Efficiency of producer (hot gas)	—	94.99
Producer gas at entrance to regenerators	6,504,713	—
Efficiency of producer	—	91.77
Heat in producer gas after passing through the regenerators	7,286,451	—
Heat gained in the regenerators	781,738	—
Heat in air before passing to regenerators	218,137	—
Heat in air after passing through regenerators	3,884,555	—
Heat gained by air in regenerators	3,666,418	—
Heat in gas and air going to furnace	11,171,006	—
Heat in materials charged into furnace	503,144	—
Heat generated by oxidation in furnace	1,072,904	—
Total heat delivered to furnace	12,747,054	100.00
Heat absorbed in reduction	750,506	5.88
Heat absorbed in slag formation	372,894	2.92
Heat absorbed in melting steel	1,289,196	10.11
Total heat used in useful work	2,412,596	18.91
Heat in gases passing to regenerators	9,715,015	76.21
Heat loss in CO gas unburned	53,933	0.42
Heat loss by radiation, etc., furnace proper	565,510	4.46
Heat in gases passing out of regenerators	4,152,723	32.57
Heat deposited in regenerators	5,616,225	44.06
Heat taken out by air and gas in regeneration	4,448,156	34.89
Efficiency of regenerators	—	79.22
Heat loss in flue to stack	287,373	2.25
Heat going up the stack	3,865,350	30.32
Total heat delivered or generated in furnace	12,747,054	100.00
Useful work	2,412,596	18.91
Radiation at furnace	565,510	4.46
Heating of regenerators	5,616,225	44.06
Radiation in flue	287,373	2.25
Loss up stack	3,865,350	30.32
Total	12,747,054	100.00

From the above heat balance it will be noted that the amount of heat actually used in the melting of the steel amounts to but 10.11 per cent. of the heat in the fuel, and the total amount of heat used in performing useful work is 18.91 per cent.; that is, the efficiency of an open-hearth furnace, giving the furnace credit for reduction, slag formation, and melting metal, is less than 20 per cent. There are a number of ways of utilising the waste heat from the furnace, one of which is by means of waste-heat boilers connected to the stack.

If it were the practice to have all furnaces equipped with a recording mechanism which would show the reversals, the superintendent would be aware of what took place at all hours, and, by paying more attention to the utilisation of heat in a furnace, would have a very good opportunity to effect economy.

There is a wide discrepancy in open-hearth design, as may be noted by the following :—

Plant.	Capacity.	Hearth.
	Tons.	Ft. in. Ft. in.
Duquesne Works, Carnegie Co.	60	32 0 by 14 9
Ohio Works	60	29 0 by 14 11
Gary Works, U.S. Steel Corp.	60	40 0 by 15 3
Republic Iron and Steel Co.	60	32 0 by 15 0
Lackawanna Steel and Iron Co.	60	43 0 by 16 9

There is an even greater variation in the dimensions of the regenerators, flues, etc., in the above furnaces.

C

* "Metallurgical and Chemical Engineering."

Steel Additions in the Ironfoundry Cupola.

Considerable prominence has recently been given to the practice of adding steel, in the form of turnings, punchings and other mild-steel scrap, to ordinary iron mixtures in the foundry cupola. This practice has existed for years, though on a comparatively small scale, and more in America than this country, but has only recently been conducted on recognised and systematic lines. Concurrent with the new prominence given to this work, there have been put forward various more or less reliable claims regarding the advantages to be gained by steel additions. There is no doubt that over a fairly wide range of mixtures some improvement may be effected in this way; but a consideration of the action of steel in the cupola and its effect on the mixture will indicate the limitations and show that where high test results and good wearing qualities are sought, and irregularities are to be avoided, a suitable selection of high-class pig-iron is the best and only proper material to use. Nevertheless, when works practice definitely shows some mixtures considerably improved by the addition of steel, it remains to be considered in what way this result is effected. The actual effect is to give a tougher and closer-grained iron, with resultant higher tensile and transverse test results, and in some classes of work better wearing qualities.

Until recently a general impression existed that by adding steel the properties of steel were being conferred upon the iron approximately in proportion to the steel additions. A moment's thought, however, will expose the fallacy of this assumption, even if an examination of the resulting product did not do so. When such additions are made, the result is neither more nor less than a cast iron (differing, of course, in the proportion of metalloids contained from a similar mixture without steel additions), no matter what proportion of steel be added. Enquiry may here be made as to the phenomenon of steel melting in the cupola at a temperature below that required for low-carbon steel, and also as to the variation or alteration in analysis obtained by this process. The simple explanation of mild steel melting at cupola temperatures has for some time been fairly well understood in some quarters. (The melting of steel in the cupola, of course, is not by any means new, as any Bessemer steel founder will know). It is fairly obvious that while the cupola temperature, which may be tentatively stated as up to (perhaps over) 1,300 deg. C., is well below the melting point of mild steel, it is sufficiently high to render the steel extremely hot, and in this condition, in contact with the carbon of the charge, that carbon is absorbed in accordance with well-understood chemical laws, much on the same lines that cementation of iron for blister steel takes place. The cementation of steel in the cupola naturally is a very much more rapid process, by reason of the high temperature, with the result that the melting point of the iron-carbon alloy thus produced is rapidly brought down to a point corresponding with the cupola temperature. The metal is thus melted before it becomes a fully saturated alloy, though the absorption of carbon does not stop until it loses contact with the coke in the cupola. Since the outside of the steel is the first to come into contact with the carbon and reduce the melting point, the process of melting proceeds rapidly from the exterior until the whole steel has been reduced to a molten high-carbon alloy, which falls into the other metal in the cupola.

In a Paper recently presented before the British Foundrymen's Association, Mr. M. Riddell referred to the equilibrium diagram of the iron-carbon series as indicating the amount of carbon which would be absorbed at the cupola temperature, his calculation being based on the freezing-point curve or *liquidus* of the diagram. The statement was that since that curve indicated the melting point of iron-carbon alloys at different temperatures, the point corresponding to the cupola temperature would give the amount of carbon absorbed before the steel became molten. On this basis the assumption was made that the amount of carbon absorbed would be from 1.7 to 2 per cent. This assumption, however, quite ignores the fact that the absorption of carbon is not dependent upon the melting point of the alloy at cupola temperature unless the metal on melting is immediately removed from contact with the carbon. The saturation point at that temperature—an entirely different thing—is the main consideration in actual practice. Saturation in the case of steel melted in the cupola is controlled by both time and temperature, and both must be fully considered in such a calculation; and under the same conditions, increase of time and decrease of temperature, or alternatively increase of temperature and decrease of time, will give the same results as regards carbon absorption—of course within certain limits. This will be appreciated on reference to cementation phenomena where up to 2 per cent. carbon can be absorbed by solid iron at a temperature well below 1,000 deg. C. over extended time. It is fairly obvious that the assumpton put forward in the above-mentioned Paper cannot hold good, since it involves the diminution of absorption with increase in temperature—an assumption which is contrary to well-known laws, since the carbon content of iron has been increased to more than double the eutectic concentration by means of excessive temperature. Mr. Riddell has apparently overlooked the fact that the equilibrium diagram assumes equilibrium, a condition that does not obtain during the melting process. Given a definite alloy with all the constituents in solution, and temperature the only variable, the phase rule may be accepted as applying. But in the presence of excessive carbon an unsaturated iron cannot be considered in the light of the phase rule, unless full time for the establishment of equilibrium is allowed, *i.e.*, time for the full absorption of carbon for the temperature obtaining. But in any case the freezing-point curve of the diagram can only be applied if the iron is maintained in contact with the carbon until molten and then removed from contact immediately. Such, of course, is not the case in cupola practice. Also it must be borne in mind that carbon absorption starts before the melting zone, and hence were the *liquidus* curve applicable, there would be a possibility of carbon absorption up to saturation point for the temperatures prior to the melting zone. Were the passage of the stock through the cupola sufficiently prolonged, it is quite reasonable to expect that at 1,300 deg. C. the iron would absorb nearly 5 per cent. carbon, which would be partly thrown out as kish on cooling, until the final carbon content was reduced to the eutectic composition (about 4.29 per cent. for a pure iron-carbon alloy). This composition with ordinary mild steel of, say, 0.06 per cent. silicon and 0.80 per cent. manganese, would probably be about 4.20 per cent. of carbon. In

cupola working, however, the time of contact is limited by the duration of travel down the furnace and through the melting zone. (Where the metal is held for a time in the well of the cupola, there is also further contact with the coke; but it is doubtful whether that contact is greatly effective in further carburising the metal.) On this account the absorption of carbon by the metal, expressed diagrammatically, probably follows the dotted curve shown in Fig. 1. Absorption of carbon commences in the cooler zones and continues in accordance with the time of passage, increasing as the hotter zones are reached, and attaining a maximum at the melting zone of the cupola, at which maximum point the absorption continues until the melting zone is passed, then practically ceases, as indicated in the curve. The significance of this lies in the fact that the maximum temperature of the cupola sets the limit of absorption of carbon by the steel, and hence the peak of the curve and the drop may occur at various points, as indicated by the dotted lines *a*, *b*, *c*, *d*. If that peak occurs at any point on the diagram below the *liquidus*, the steel does not become molten, unless by contact with the molten iron below. For this reason there is a minimum temperature below which steel cannot be melted in the cupola. If, on

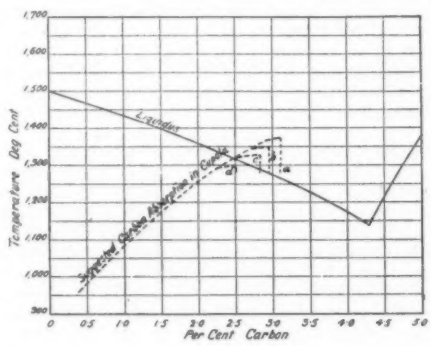


FIG. 1.

the other hand, the absorption curve goes above the *liquidus*, it does not stop at once, but continues by reason of the molten metal passing through the incandescent melting zone to the hearth, at which point the curve may be taken as stopping. This suggested carbon-absorption curve is based merely on the writer's conclusions drawn from the examination of various odd data, and considers the time of contact with the carbon and the temperature of the cupola zones. The exact position of the curve might on experiment be proved somewhat incorrect, and, in fact, for different cupolas may vary within a certain range; but it may be taken tentatively as indicating the process. This brings us again to the point that the *time of contact with the carbon* × *temperature* is the factor controlling carbon absorption. In other words, the rate at which the stock travels down the cupola, the temperature of the various zones of the cupola (as controlled by the quality of coke, quantity and pressure of blast), are all influential. The limit of absorption is set by the saturation point, but in cupola work is never reached.

Reference may here be made to an extension of the equilibrium diagram by Ruff and Goecke,* shown in Fig 2. According to this, nearly 10 per cent. carbon can be dissolved by iron at a little over 2,200 deg. C. The lower portion of that curve only, however, is of interest in connection with cupola operations, and may be taken as indicating the maximum carbon at different possible cupola temperatures. Fig. 3 is a graphed curve showing the percentage at certain temperatures corresponding with

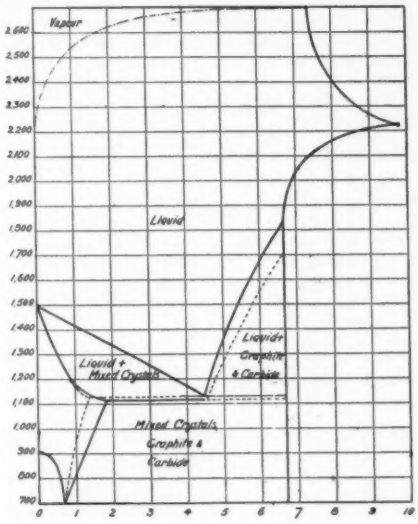


FIG. 2.

the saturation point of 2.70 per cent C., shown on the diagram

As regards the other constituents of a cupola mixture to which steel is added, Mr. Riddell assumes that these may be taken as the mean of the constituents. This, while not strictly accurate, is sufficiently so for practice. Actually there is some absorption of sulphur and a loss of silicon by oxidation. Accordingly, the addition of 20 per cent. steel of

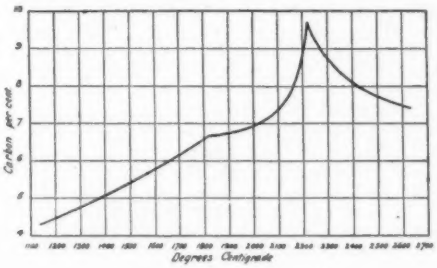


FIG. 3.

say 0.15 per cent Si. to a 2.00 per cent. Si. mixture would give a result somewhat as follows :—

Pig-iron of	2.00	% Si.
20 % steel of	0.15	,,
Silicon in mixture	1.63	,,
Oxidation loss	0.20	,,
Silicon in castings	1.43	,,

We may next enquire how these steel additions benefit the metal, since the total carbon in practice is not greatly decreased. The explanation put for-

* "Stahl and Eisen."

ward by the author of the above-mentioned Paper was that the reduction of silicon allowed a greater proportion of the carbon to be retained in the combined form; but this is not a satisfactory explanation, since the use of merely a lower silicon iron should give the same effect. Nor is it correct to assume that a reduction in the silicon alone would necessarily increase the strength and give the closer structure obtained by steel additions. In support of this may be mentioned the fact that, say 10 per cent. of mild steel (say 0.15 per cent. Si.) added to a mixture with the analysis :—

G.C.	C.C.	Si.	S.	P.	Mn.
3.00	0.48	2.30	0.075	1.55	0.50

would give approximately :—

Total C.	Si.	S.	P.	Mn.
3.4 or more.	2.0	0.075	1.40	0.50

and also a much closer and stronger structure than in the original mixture; while open-grained pigs of similar analyses to the latter are by no means unknown. The following analyses* of No. 2 irons will illustrate this :—

G.C.	C.C.	Si.	S.	P.	Mn.
3.00	0.30	2.10	0.03	0.045	1.15
2.96	0.56	1.39	0.05	0.40	1.065
3.19	trace	1.98	0.01	1.67	0.36

The effect is produced more by reason of the fact that the carbon absorbed by steel in the manner above depicted is what has been described by previous investigators as "effective carbon," *i.e.*, carbon in complete solution when the metal is molten. There is evidence that an open-grained iron with large-flaked graphite, when melted, dissolves only part of its graphite, the remainder being held practically in mechanical suspension. It has been conclusively proved that graphite produced at high temperatures is more refractory than that produced at lower temperatures. Carbon absorbed in the cupola, until it has been thrown out of solution in cooling, naturally does not assume a crystalline form, and since the whole of it which appears ultimately as graphite is thrown out of solution in a comparatively short space of time, it never assumes the large-flaked form peculiar to some hot-blast pig-irons. Consequently, graphite absorbed by steel in the cupola has much the effect of the carbon characteristic of cold-blast irons, and the grain of the casting is in many respects similar to castings from such pig. Here at once is the explanation for the increased strength of some irons by the addition of steel; and also from this it will be obvious that a really first-class close-grained iron could not be improved, and might even be detrimentally affected by such additions, the result being merely a harder and perhaps weaker iron. The assumption that in melting a large-flaked graphitic iron all the graphite does not go into complete solution explains many of the allied phenomena, for this mechanically-suspended and undissolved graphite forms nuclei for the re-crystallisation of the carbon thrown out during cooling, and hence hastens the crystal development, giving the large-flaked form again. Since at no time does the carbon absorbed in the cupola by steel assume a crystalline form until thrown out as graphite during the cooling of the casting, the graphite formation is naturally very much smaller, with the results above-outlined.

* These are makers' analyses, and while the total carbon in most irons would be higher with the silicons shown, the fact that No. 2 fractures were got with these analyses is significant.

So far the process would appear quite simple, the only necessary precaution being to ensure that the metalloids in the final mixture are not unduly reduced, so as to give over-hard iron. But trouble is very liable to be encountered by reason of imperfect mixing of the carburised steel and the molten pig, with the result that very irregular and unsatisfactory results may readily be got, particularly with high proportions of steel added. For this reason some regular users of steel additions place the maximum limit at 10 per cent., and cannot use more without running into pigs and re-melting. The trouble incurred by reason of this imperfect mixing results from the different specific gravities of the metals, or rather alloys, comprising the whole, this difference being largely attributable to the variation in the condition of the carbon. The final mixture comprises two quite distinct alloys, the one being practically a pure iron-carbon and the other an ordinary pig-iron; and to obtain a homogeneous mixture requires more than ordinary cupola tapping temperatures and the simple dropping of the one alloy into the other in the cupola hearth. A slight dulness of temperature that would not affect pig-iron alone will readily prevent the proper mixing of carburised steel and pig-iron. It would almost appear as though the metal often did not become properly mixed until the final pouring into the mould, for the effect of allowing it to cool in the ladle is seen in the castings, which in such cases may be full of "cold-shot." This characteristic of pig-iron with steel additions to "go off," or quickly lose its fluidity, is one of the most important points to observe, and necessitates good hot pouring.

Another source of trouble is the liability of oxidation of the metal through the high temperature required for the efficient mixing of the alloys. If that temperature is not attained a very irregular metal is produced; if it is attained there is almost inevitably some considerable oxidation of the metal in melting. To overcome this the addition of ferro-manganese has proved effective. Some users claim that the manganese assists by aiding the absorption of carbon; but it is difficult to see how this effect is obtained unless the manganese is actually in the steel itself. The more plausible conclusion is that it acts as a deoxidiser at the high temperatures of the metal, that same high temperature allowing the absorption of the high carbon.

Summing up the question, it may be fairly claimed that the practice of adding steel to cupola mixtures has in many instances decided advantages. But the mechanism of the process requires to be properly understood, particularly when large additions are made. Further, there is as yet little evidence of advantage where first-class British irons are used, except, it may be, in the matter of cost; and here the saving in cost of metal may be quite offset by wastage if the practice is not thoroughly understood and properly carried out.

British Foundrymen's Association

Scottish Branch.—The office bearers and Council members for the new session are as follows:—President, Prof. A. Campion, F.I.C., F.C.S.; Vice-Presidents, Mr. Matt. Riddell and Mr. L. P. Mackenzie; Treasurer, Mr. John Logan, Foundry Cottage, Stevenston; Hon. Secretary, Mr. W. C. Gray, A.R.T.C., Royal Technical College, Glasgow; Council :—Messrs. Wm. Bell, B. Doulton, Wm. Hudson, A. Laurie, A. Littlejohn, R. R. McGowan and G. Watt.

An Interesting Cupola Explosion.

A recent article in "Stahl und Eisen," by R. Fichtner (translated in "The Iron Age"), describes a remarkable cupola explosion and its probable causes. The explosion occurred at a plant in Bohemia. The plan of the furnaces is shown in Fig. 1. The two cupolas, Nos. 1 and 2, are connected to an Enke blower, and by means of two valves the blast can be admitted to one furnace while the other is not running. The explosion occurred in No. 2 cupola (the details of the furnace are shown in Fig. 2), the normal output of which is four tons per hour. The tuyere arrangement is rather unusual. There is a lower ring of four circular tuyeres, and four series vertically arranged, but examination after the explosion showed that the upper vertical tuyeres were bricked up. The cupola, which was 18 years old, was freshly lined and had been in operation for three days without developing any irregularities. The blast pressure shortly before the explosion was 0.78 lb. per sq. in., 21 tons of metal had been tapped, and at the moment of explosion the furnace contained three tons of unmelted metal and about half a ton of molten iron. The explosion was very violent, and the shell was torn open at the riveted seam. The blowing engine was blown to pieces, but the blast mains were

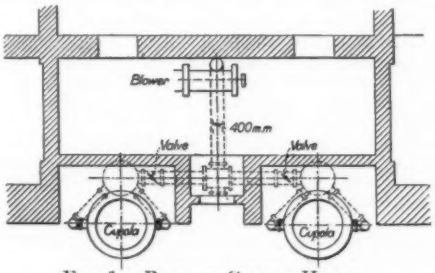


Fig. 1.—Plan of Cupola House.

unharmed. Four men were more or less seriously hurt. Regarding conditions shortly before the explosion, the workmen reported that nothing special was noticed. The charge did not stick or hang, but the blue flames above the charge were much smaller in amount than usual. The blast was put on three hours before the explosion and was not shut down except for a few seconds, about one minute before the explosion, due to the belt slipping from the pulley. It may be mentioned that none of the charge was blown through the charging door or shaft by the explosion, the valve in the blast main was open and could not close automatically, and water was not used around the cupola.

The operation of a cupola produces carbonic acid and carbonic oxide gas, together with nitrogen and often free oxygen. Carbonic oxide possesses the property of forming an inflammable or explosive mixture with air, not when present in any amount, but within certain well-defined limits, the range within these limits being known as the explosion range. These limits for various gases are:—

	Lower limit, per cent.	Upper limit, per cent.
Carbonic oxide	16.4 and	75.1
Hydrogen	9.4 and	66.5
Water gas	12.3 and	66.9
Acetylene	3.2 and	52.4
Illuminating gas	7.8 and	19.2

It is evident, therefore, that carbon monoxide has the greatest explosion range, but that its low limit is above that of other gases. The large range is not so important in the case under consideration, because even with the best gas-producer practice only about 33 per cent. carbon monoxide is present in the gas. If the combustion of the coke in cupola practice is incomplete considerable carbon monoxide may be formed, and with the entrance of air an explosive mixture can form and cause an explosion.

Recent researches of Dr. Hüser have shown that when starting up a cupola the action is similar to that

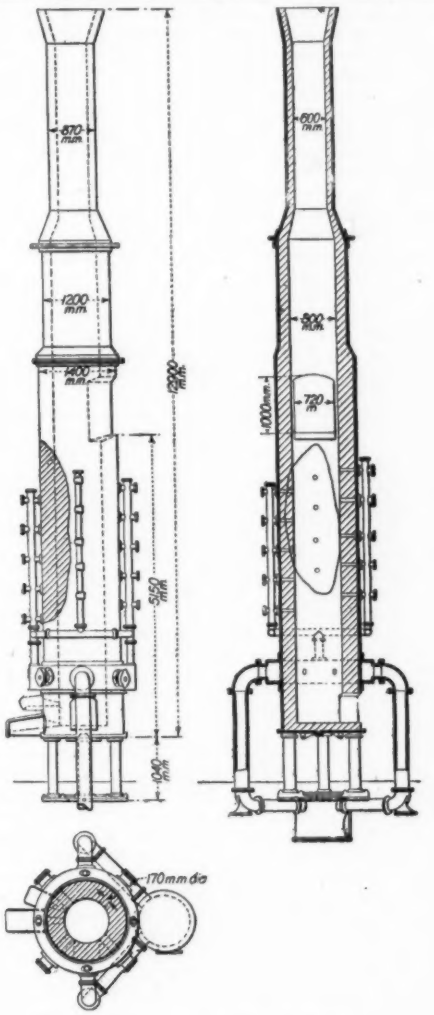


Fig. 2.—Details of No. 2 Cupola.

of a gas producer, and considerable carbon monoxide is formed. Only after a considerable time, half an hour to one hour, does the carbon dioxide percentage increase to the normal amount. Up to this time the upper part of the cupola is filled with blue clouds of inflammable gas, which ignite as the upper layers of the charge become hotter, often with a loud noise and explosive violence. These explosions can easily

be prevented by igniting the gases after admitting the blast with a lighted ball of oily waste. This flame above the charge does not always appear accompanied by an explosion, but usually ignites quietly soon after starting. Such an explosion can also take place after the furnace has been in blast a considerable time. It often happens during operation that the blast is stopped for some reason. The coke is still incandescent, and as the supply of air is shut off the carbon dioxide present is quickly reduced to monoxide and fills the whole furnace. If the valve is not closed it will enter the blast main when the stoppage is a long one. Then, when the blast is again started, the air enters very quickly and forms a mixture with the carbon monoxide. In the lower part of the cupola it burns to dioxide, the flame penetrates the upper part of the cupola, where the charge is too cold to ignite the gas, but where the air has already penetrated. There is an explosion which usually makes a loud noise and expels a large flame from the throat. Dirty tuyeres may give rise to similar results because only a moderate amount of air is admitted and carbon monoxide can form. Then when the tuyeres are cleaned the air rushes in quickly and an explosive mixture may easily be the result. A hanging of the charge, the formation of scaffolds and hollow places in which carbon monoxide may collect may also cause an explosion.

In the particular case under discussion it is known that shortly before the occurrence the blast was off for several seconds. The exact time is open to doubt; but the fact of the belt slipping is also important. The blast entering the furnace would be intermittent, combustion would cease, and carbonic acid gas be reduced, the furnace in the short interval filling with carbon monoxide. After the belt was adjusted the blast was again introduced in full force, and the explosion took place. It is probable that exactly the right amount of air was introduced to give the proper mixture for the greatest possible explosion. From the fact that none of the charge was blown from the throat, it is presumed that the shell of this 18-year-old veteran was not in very good condition. It tore at a riveted joint and it is not improbable that some rivets had been sheared off, and the steel badly rusted. The charge, which may have scaffolded, offered more resistance than the shell. The fact that there was but little flame at the throat was probably due to the intermittent character of the blast.

To avoid such explosions, before starting great care should be taken that the cupola is thoroughly heated through. Regular and uniform charging, with the avoidance of very large pieces, tends to prevent hanging and scaffolding. The tuyeres should always be kept clean, and if the blast is shut off for any reason, one or more tuyeres should be opened to the air. This allows air to enter the cupola under the influence of the draft of the stack, and a collection of considerable carbonic oxide in the furnace is prevented. Also a valve should be placed in the blast main close to the furnace so it can be closed when the blast is off to prevent inflammable gases entering the mains; then when the blast is started up again it should be opened slowly. If the cupola has a forehearth, the latter should be provided with a valve at its highest point which can be opened from time to time, if the blast is shut off, to allow the gases to stream out and burn in the air. Further, when the furnace is re-lined, the bricks should not be set close up against the shell, but space should be left for an outside layer of sand. This allows for the expansion of the bricks which otherwise would bring about severe stresses on the rivets and possibly shear some of them, thus weakening the shell. Finally, the blowing engines should be given constant supervision to see that everything is in good condition.

Hints for Young Patternmakers.

Fillets may add to the appearance of a casting; but their main objective is to strengthen it.

Iron crystallises at right angles to its cooling surface; therefore if corners are left square the line of junction of the crystalline structure is essentially weak, tending to produce a cracked or easily-fractured casting.

Fillets, properly affixed to the pattern, add considerably to its strength, and during moulding give a cleaner "lift."

Fixed-on fillets, of either leather or wood, should be nailed into position. Glue and varnish are not permanent adhesives.

In making good fillets, allow the edges to remain slightly "thick" rather than feathered, which thickness can be more cleanly and neatly sand-papered down when they are fixed into position. They are also less liable to split during fixing.

Fillets working from the solid stuff are preferable to those of wood, lead, or leather, afterwards attached. This method may add to a pattern's cost, but is relatively cheaper for standard work.

Beeswax for filleting purposes should only be used when the fillets are of a small size. Resin should be added to the wax to form a bond and hardener.

Avoid putty and plaster of Paris for filleting. When dry they are both very liable to fall out, which is not conducive to making a mould perfect, or a moulder happy.

For a "one-off" job, fillets in the pattern may be dispensed with; but where they are required in the casting, should be marked clearly and *brilliantly* as an intimation to the moulder to form them up in his mould.

Building-up in segments or by laminations are the same, with a difference. A segment is a true portion of a circle, but a lamination may be a layer of any shape or form.

A pattern formed by segments or laminations is considerably stronger and less liable to shrink or warp than if made from the solid stuff.

The greater the number of courses in a built-up job, the greater the pattern's strength and durability.

Short-grain in a segment or lamina should be reduced to a minimum, consistent with the economical use of timber.

The length of a segment's chord is governed by the amount of short-grain produced. The greater the amount of short-grain produced the more necessary does it become to reduce it by shortening the chord's length.

Segments should, if possible, be built upon a face-plate and the joints faced in the lathe. This is quicker, easier, and more economical than by the plane.

When turning segment work of a spherical form, mark out on each layer where the screws or nails (for fixing) have to enter. Also judge correctly the angle at which they have to be driven in. This also applies to angular work, and may also save a lot of trouble in plain cylindrical work.

To encounter a nail or screw during turning weakens the pattern and—tends to imperil one's soul.

Wood pegs are equally as efficient as either screws or nails. They should be a tight fit to the bored hole, but slightly less in length than the bored depth.

If wood pegs are forced in too tightly, they tend to split the wood, or if too long, raise the joint. They should be driven home gently but firmly, as this method of fixing is anything but fool-proof.

Pegs should be split and the corners taken off with the chisel. It is *not* necessary to make them truly cylindrical.

Foundry Sands and their Treatment.

By Algernon Lewin Curtis, M.E.

(*Continued from page 590.*)

Practical Methods of Testing Moulding Materials by Heat.

As it is scarcely possible in the average foundry to test fresh moulding mixtures from day to day by means of a trial cast, some practical method of ascertaining the fusing points of sand mixtures in the laboratory is next in importance to the actual cast itself. It should be seldom necessary in modern foundry practice to have to requisition a ton or more of moulding material* in order to ascertain by trial casts whether it is specially suited for the particular work. With the proper apparatus and instruments, a sufficiently accurate diagnosis of a moulding material can be made in a few hours, so as to judge whether a trial cast in the foundry is justified. In large foundries (especially those making steel castings) where fresh moulding sands and "compo" are constantly being tried, it would greatly facilitate the work, and save both time and expense, to adopt some system for making tests of such moulding materials. There are several methods for conducting these tests, and those which the author has found best to adopt, as being the most practical to foundrymen, are given below.

First, it is necessary to procure a source of great heat, that can be adjusted in a few seconds. Second, some standard method should be adopted for accurately measuring in a similar period the intensity of such heat. Third, means must be provided over and above the naked eye or common lens for noting the appearance of any material, both before and after it has been exposed to such heat. In addition to the above, a standard mould or core box for making the test-pieces should be adopted, which will enable specimens to be handled without fear of breakage, and which will also exhibit on their surfaces fair signs of the heat to which they have been exposed.

Several sources of artificial heat are open to the foundryman for this work, all of which possess their own particular advantages. These are as follows in progressive order of heating capacity:—(1) The oxy-coal-gas blow-pipe, (2) the oxy-benz blow-pipe, (3) the oxy-hydrogen blow-pipe, (4) the oxy-acetylene blow-pipe, (5) the oxygen furnace, (6) the electrical furnace.

Although the first cannot produce heats equal to the others, its flame is sufficient to fuse the surface of any moulding material likely to be put under it. The flame of an oxy-coal-gas blow-pipe cannot perhaps be as easily adjusted as that from oxy-acetylene, yet its great advantage is the fact that it can be connected on to any gas main, and oxygen cylinders are easily procured. Of course, for welding purposes coal gas is not as good as acetylene, owing to the impurities always present in coal gas, but this does not affect very much the fusing of a moulding material.

The oxy-benz system, which is just emerging from the experimental stage, is useful when coal gas or acetylene cannot be obtained. In this case benzol (C_6 H_6) is employed as a liquid fuel substitute for coal-gas or acetylene. This liquid fuel is automatically fed to the blow-pipe, where it is vaporised and burnt in oxygen, producing a flame very similar to that from an oxy-acetylene blow-pipe. Its calorific value, however, is not as high as that of oxy-acetylene, but higher than those of oxy-hydrogen or oxy-coal-gas. One disadvantage of this system is the possible danger of its use in a chemical laboratory, though it offers some advantage in economy.

The oxy-hydrogen system on the Continent has been in use some time, probably due to the introduction of electrolytic plants for separating oxygen and hydrogen from water, it thereby becoming necessary to find a market for the latter gas, in order to sell oxygen at remunerative prices. Hydrogen in combustion yields heat to the amount of 300 B.T.U. per cubic foot, but as at least four volumes of hydrogen must be employed with every volume of oxygen to obtain the best results, the true calorific value per cubic foot is about 175 B.T.U., as compared with 1,500 B.T.U. in the case of acetylene. Where hydrogen and oxygen gases are used extensively, they are generally produced by the electrolysis of water, therefore their combustion which reforms that element may be described as the final stage in the cycle of change which the water has undergone. As hydrogen and oxygen have a strong affinity for each other, their combustion occurs with great explosive violence, the product being water in the form of steam. The steam is, of course, superheated in the hot zone of the flame, and as steam is not stable at high temperatures it is bound to be re-decomposed into its elements in the flame. This decomposition or disassociation will begin at a temperature below 2,000 deg. Fahr., and continue with progressive violence until the temperature has reached 4,000 deg. Fahr., above which temperature the existence of steam as such in the hot zone of the flame is altogether impossible. The process of disassociation involves a consumption of heat which is abstracted from the flame itself, and it leads to the existence of free oxygen in the flame, with a subsequent oxidising effect. This can only be avoided by feeding into the flame a large excess of hydrogen (in practice from four to five volumes of hydrogen to one of oxygen). The large excess of hydrogen required to prevent oxidation furnishes in itself one reason why the use of the blow-pipe by means of the oxy-hydrogen flame is frequently uneconomical. Although the system is a good one, producing greater heat than oxy-coal-gas, where this latter can be procured in a foundry the extra heat from hydrogen hardly justifies the expense of its use, except in certain cases.

The fourth system of heat, viz., by oxy-acetylene, is undoubtedly the best, its only and chief objection being the expense of plant for generating acetylene gas (unless acetylene cylinders are used, which are also expensive), the apparatus for which it is not always convenient to have in or adjoining a chemical laboratory. The temperature of flame in a good oxy-acetylene blow-pipe reaches approximately 6,000 deg. Fahr., only slightly less than that of the

* The term "material" is preferred to "sand," as it covers all those substances, whether artificial or natural, which are used in making cores or moulds for casting metals.

carbon arc. This high temperature is mainly brought about by the combustion of carbon to carbon-dioxide. The chemical combustion of acetylene (C_2 H_2) and the physical conditions which arise during its combustion in oxygen differ essentially from those which occur in the case of hydrogen. Acetylene has a heating value o fabout 1,500 B.T.U. per cub. ft. It is an endothermic gas composed approximately of 92.5 per cent. carbon and 7.5 per cent. hydrogen, which in combustion with oxygen form carbon-dioxide and water. In consequence of the high flame temperature, however, the water formed by this primary combustion is disassociated into hydrogen and oxygen, the latter element combining at once in the flame with the carbon of the acetylene to form carbon-dioxide, whilst the hydrogen can only combine with the oxygen which has passed out of the hottest zone of flame, and thus does not involve a consumption of heat at the expense of the hottest part. It is claimed by authorities in oxy-acetylene welding that the hydrogen forms a relatively cool jacket round the hot flame produced by the combustion of carbon in oxygen, and that as the hydrogen is not able to combine with oxygen at the very high temperature which exists within the inner

FIG. 1.—WEDGE-SHAPED TEST-PIECE.

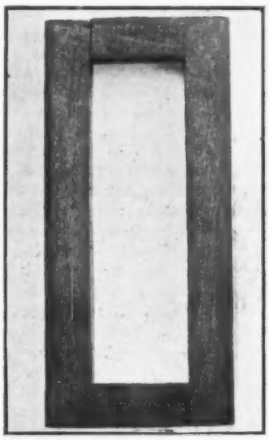


FIG. 2.—BOX FOR MOULDING RECTANGULAR TEST-PIECE.

zone, it remains temporarily in a free state, protecting the inner zone in a measure from loss of heat, whilst largely excluding the tendency to oxidation.

Theoretically 2½ volumes of oxygen are required for the complete combustion of one volume of acetylene, but in practice it has been found that to get the best results from a blow-pipe 1.5 volumes of oxygen are necessary to one volume of acetylene. From the above it can readily be seen that the oxy-acetylene blow-pipe is the best for testing the refractory qualities of any moulding material where the factor of expense is not the chief consideration. The application of the electric furnace has, as far as the author can ascertain, been little used in the testing of moulding materials, and it is hoped that some enterprising chemist or metallurgist will make use of this method.

The fifth process, which is also a valuable auxiliary to the blow-pipe, is the oxygen furnace, which is extremely useful for the rapid fusion of metals or treatment of refractory substances at all temperatures. This furnace is entirely self-acting, and can be worked for a considerable period with a 20-ft. cylinder of oxygen. The temperature is under the most perfect control from a red heat to the almost instantaneous fusion of the most refractory crucibles. A very fine jet of compressed oxygen is first mixed with air, then with coal-gas, the pressure of the

FIG. 3.—RECTANGULAR TEST-PIECE.

oxygen being utilised to make this mixture and blow it into the furnace chamber at a high speed. Fig. 5 shows an oxygen furnace made by Messrs. Fletcher, Russell & Company, Limited, Warrington.

The author's experience justifies the statement that oxy-acetylene is the best for use with the blow-pipe if the acetylene can be generated away from the laboratory. Next to oxy-acetylene the oxy-coal-

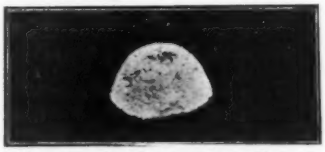


FIG. 4.—SEMI-SPHERICAL TEST-PIECE.

gas system offers the most advantages, especially, as previously mentioned, the advantages of being able to connect on to a gas main direct. The use of oxygen also enables one cylinder of oxygen to work both blow-pipe and furnace—which is a great advantage if it is desired to cast metal in any particular moulding mixture.

Before proceeding to describe in detail the methods of producing and measuring the heat necessary for

FIG. 5.—OXYGEN FURNACE.

the purpose, it is best to consider the form or shape which specimens or test-pieces of moulding materials should be given in order to prepare them for their various examinations. When commencing this branch of research, the author adopted a wedge-shaped test-piece. This measured 3 in. long, $\frac{11}{16}$ in. wide, with one end ¼ in. thick, the other tapering

down to $\frac{1}{16}$ in. (see Fig. 1). It was thought that a wedge-shaped test-piece would give a better indication of the cohesive properties of a moulding material when making same, also convey a more accurate idea of the expansive nature of the material when being dried, and before the application of the blow-pipe. Although the wedge-shaped form answered well in these respects, it had to be abandoned on account of the number of specimens broken in handling, owing to their fragile nature. Another objection to this form of test-piece was the size, which had ultimately to be reduced so as to easily fit on a 3 in. × 1 in. microscopic glass slip and allow room for a label to be affixed to the latter as well. After trying a number of different styles and shapes for test-pieces, it was finally resolved to adopt the following standard, viz., a specimen or test-piece $2\frac{1}{2}$ in. long × $\frac{3}{4}$ in. wide × $\frac{1}{4}$ in. thick. This test-piece is made in an ordinary core-box (see Fig. 2), consisting of two "L" shaped pieces of hard wood, both ends dowelled so that they can be drawn off the specimen without fracturing it. A core-box of this size can be put on a 3 in. × 1 in. glass slip during the process of ramming the material, the test-piece then removed to the oven or microscope still on the glass slip, the latter only being removed when the specimen is placed before the blow-pipe or in the oxygen furnace. Finally, all the specimens can be mounted on their respective slips, by means of microscopic cement, for purposes of reference. The flat surface of a specimen (as shown in Fig. 3) from the core-box illustrated, allows heat from a blowpipe to be more evenly distributed over its entire surface, whereas in a wedge-shaped specimen the heat was not entirely uniform; also when examining a perfectly flat surface under the microscope, focussing with the fine adjustment alone was necessary, while with the wedge-shaped test-piece considerable focussing with the coarse adjustment was involved.

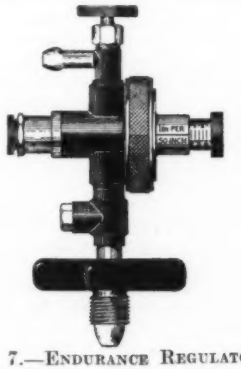


FIG. 7.—ENDURANCE REGULATOR.

It should always be borne in mind when conducting tests of this character that the test-pieces represent a section of a mould, and therefore must be treated as such, by facing with blacklead, pure plumbago, etc. On account of the small thickness of test-piece, viz., $\frac{1}{4}$ in., the material used should represent the character of a facing sand as far as possible. Another form of test-piece which can be used when it is sometimes necessary to quickly diagnose the refractory proportion of a loamy material is of the semi-spherical form shown in Fig. 4, which is $\frac{7}{8}$ in. in diameter. This latter form of specimen does not possess the advantages of one rectangular in shape, but on account of the ease and speed with which test-pieces can be prepared, the shape is very welcome when having to test a large number of materials quickly.

Before an oxy-coal gas or oxy-acetylene blow-pipe can be used with the best results, some little know-

FIG. 6.—BLOW-PIPE AND INJECTOR.

ledge of the complete apparatus is necessary. With the oxy-coal-gas system, compressed oxygen takes the place of air, and ordinary town gas the place of hydrogen used in the old system. The blow-pipe used in this process is constructed on the injector principle. By its use oxygen is delivered under slight pressure from an ordinary cylinder, and draws the coal-gas direct from the town supply, finally discharging the mixed gases in the right proportions through the nozzle of blow-pipe.

In Fig. 6 is shown the blow-pipe used by the author (made by the British Oxygen Company, Limited). It is fitted with two inlets, viz., H (coal-gas) O (oxygen); the oxygen inlet has a kind of injector fitted, as shown, and by this means the pressure of oxygen, which is adjustable, coming from the cylinder is made to suck the necessary supply of coal-gas through the inlet H of the blow-pipe, and deliver both gases when mixed and under sufficient pressure to the platinum-lined burner nozzle.

It is necessary to have an automatic regulator, as shown in Fig. 7, fitted on to the oxygen cylinder, to automatically deliver gas from the cylinder at any pressure up to 30 lbs. per sq. in. This is also fitted with a gas-expansion device, which obviates ignition

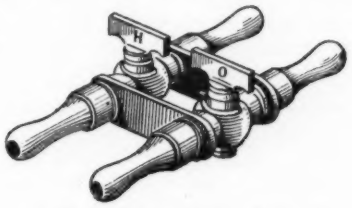


FIG. 8.—SHOULDER TAPS.

risk at the valve seat. The adjustable screwed socket on the side of regulator is graduated in lbs. per sq. in., so by this means the usual low-pressure gauge can be dispensed with. It is also desirable, though not absolutely necessary, to have fitted to the oxygen cylinder a pressure gauge to enable the contents to be easily checked preparatory to requisitioning a further supply of oxygen. A pair of shoulder taps in one (see Fig. 8) is necessary to connect up the oxygen cylinder and the coal-gas supply with the blow-pipe by rubber tubing. The connection from the town-gas supply into the laboratory for this work should be $\frac{3}{8}$ in. in diameter, and for connecting the oxygen cylinder to the shoulder

taps and then on to the blow-pipe, the best rubber tubing is necessary, having an internal diameter of ¼ in. For connecting the town gas to the shoulder taps and blow-pipe, less substantial rubber tubing can be used, also ¼ in. internal diameter. Oxygen cylinders of 40 ft. capacity are best suited for this work, these being covered with hemp or coil covers and weighing 45 lbs.

Having arranged the oxygen cylinder in a convenient corner of the laboratory away from any source of heat, and where it will not be jarred, the blow-pipe should be fitted to an adjustable vertical stand (Fig. 5, p. 22 of the January issue of the FOUNDRY TRADE JOURNAL shows a convenient stand) on a rectangular table sufficiently large to accommodate a small travelling carriage, the necessary rubber tubing, and a Fèry absorption pyrometer. The rubber tubing should be wired on to all joints, as it may be blown off with the pressure of oxygen, and it should be sufficiently long to provide plenty of room for adjustment. It is necessary to have a small balanced travelling carriage running under the blow-pipe on wheels, upon which is placed a fire brick, and on the fire brick test-pieces, in order that the latter can be travelled up and down under the blow-pipe flame. By this means the blow-pipe flame can be changed almost instantaneously from one specimen to another without losing or increasing any of its heat by shutting off oxygen or coal-gas taps. One very necessary thing

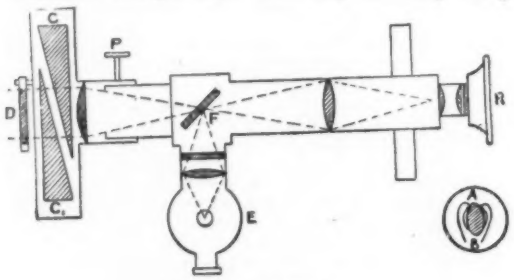


FIG. 9.—MIRROR.

must be borne in mind, viz., that the working of all the apparatus should be under perfect control of the operator, who has little or no time to run and shut off oxygen at the cylinder, or attend to anything beyond watching the instrument, blow-pipe flame, and physical change in the test piece. A travelling carriage made of wood or iron, and fitted with three or four wheels, answers the purpose. At each end of the carriage wires or cat-gut strings should be fixed which run over pulleys fastened in a line with the track of carriage. To the ends of these wires or strings are attached weights so the whole carriage is in a state of equilibrium or balance. By pulling a lever fixed to one of the strings, or the actual string itself, the test pieces resting on the fire brick, which is laid on the travelling carriage, can be moved in a second either to or from the flame of the blow-pipe.

With the above apparatus moulding material test-pieces can be easily fused to a glass, though this is not altogether what is required, as all material will fuse if exposed to a blow-pipe flame long enough. What is required is to ascertain the temperature a particular moulding material in the form of a test-piece will melt at, and for this purpose is required some reliable instrument such as a Fèry absorption pyrometer. The instrument used by the author (made by the Cambridge Scientific Instrument Company, Limited), is an improved form of the original optical pyrometer of Le Chatelier, consisting of a telescope which carries a small comparison lamp. (E, Fig. 9.) This lamp is filled with pure amyl-acetate (oil of pear) and the image of the flame is projected on to a mirror F, at 45 deg. placed at the principal focus of the telescope. This mirror is only silvered over at a small patch (A. B., Fig. 8). The telescope is focussed on to the test piece, the temperature of which it is desired to measure, being viewed on either side of the silvered patch. A pair of absorbing glass wedges C., C., are placed in front of the objective of the telescope, and these wedges are moved laterally by means of a rack and pinion screw, until the light from the object under observation is made photometrically equal to that emitted by the standard lamp. By arranging the absorbing glasses to partially absorb the light either from the standard lamp or from the hot body (in this case a test-piece) whose temperature is under measurement, the instrument can be given three different ranges of temperature. These are approximately 800 deg. to 1,500 deg. C., 1,000 deg. to 2,500 deg. C., and 1,400 to 5,800 deg. C. It will thus be seen that the instrument has a very wide scope, covering practically the whole range of temperatures likely to be met with when testing moulding materials. The lamp which fits in chimney slide burns pure acetate of amyl (oil of pear), and the height of its flame is adjusted by the makers to give the best results. Also, final adjustments are made at the National Physical Laboratory, Teddington, when after testing a mark is made on chimney slot for the purpose of enabling the operator to keep the flame tip always level with this predetermined mark. When adjusting the tip of this flame, the eye should be 18 in. away from the slot in a horizontal plane level with mark. The following briefly explains the theory and range of the instrument. When the intensity of the light of a particular wave length due to the radiating body has been adjusted by means of the wedges to equality with that due to the lamp, then the theory of the instrument leads to a relation of the type T, $(x-a)=-d$, where x is the reading on the scale of the instrument, T the absolute "black-body" temperature of the radiating object, and a and d are constants depending on the construction and conditions of use of the instrument. In the Fèry absorption instrument three practical scales are possible by arranging an absorbing glass in the lamp tube (which slides in and out), and a further absorbing glass in front of the wedges (which lifts up and down) at the end of the telescope in different combinations.

All readings should be taken through a red glass eye-pece fitted in the telescope which gives approximate mono-chromatic light, and care must be taken to see that all glass surfaces of the instrument are clean and free from dust before commencing to use it. Those who have never used a Fèry absorption pyrometer before would be well advised to try the instrument on the mantle of an incandescent gas lamp before using it on test-pieces either under the blow-pipe or in an oxygen furnace, in order to be able to quickly manipulate the necessary parts. The following table may be of some use to those just commencing to use this particular form of instrument. The tests should be carried out in a darkened room and the gas lamp arranged about 18 in. from the pyrometer. In using the low range or scale of the instrument for extra absorbing glass must be slid into the lamp tube, and the colour glass in front of the wedges removed. The lamp, which should burn for a few minutes before being inserted in the chimney, is then adjusted so the

tip of its flame is on a level with the mark on chimney slot. The eye-piece in the telescope is then focussed by drawing it out, so that the oval patch appears as a perfectly clear image; then the telescope as a whole is focussed by means of the rack and pinion screw on to the gas mantle. When the instrument is in complete focus the following may be observed :—

At 0 deg. on lower scale=810 deg. C., a dark oval patch on a red ground is seen. By turning the graduated temperature scale adjusting screw to 30 deg. on lower scale=981 deg. C., a dark oval patch on a less red ground is seen.

At 40 deg. on lower scale=1,050 deg. C., a dark oval patch on a blurred red ground is observed.

At 50 deg. on lower scale=1,128 deg. C., a dark oval patch showing signs of transparency is noticed on a dirty, blurred, red ground.

At 60 deg. on lower scale=1,215 deg. C., an oval patch more crimson than black is seen on a similar ground to that at 50 deg.

At 67 deg. on lower scale=1,285 deg. C. (approx.), it will be noticed that the oval patch and ground are practically the same in colour, this being the approximate temperature of gas mantle, viz., 67 deg. on the lower scale=1,280 deg. C. To take the temperature of the same gas mantle by the middle scale, the absorbing glass slide is removed from the lamp chimney, care being taken to see that there is no absorbing glass in front of the wedges, and that the tip of the lamp flame is just level with the mark on the slot.

At 0 deg. on middle scale=975 deg. C., a dark oval patch, somewhat transparent, is seen on a whitish-red ground.

At 10 deg. on middle scale=1,044 deg. C., the oval patch becomes a little more transparent, and the ground a more dull red.

At 20 deg. on middle scale=1,120 deg. C., the oval patch becomes more crimson, with less darkened edges on a dull crimson ground.

At 30 deg. on middle scale=1,207 deg. C., the oval patch becomes more crimson, with the darkened edges on a still more dull red ground.

At 39 deg. on middle scale=1,304 deg. C. (approx.), the oval patch and ground are seen to be alike in colour, being a whitish-reddish-crimson. Therefore, 39 deg. on middle scale=1,294 deg. C. (approx.), is the temperature of gas mantle. The difference in readings of 10 deg. C. was probably due to a slight change in the temperature of gas mantle, which would not have occurred had a diaphragm regulator been fitted to the gas lamp.

The above should suffice to give those who anticipate using this instrument some idea of its functions.

Pouring 250 Castings on One Runner.

The accompanying illustration shows a somewhat novel and unique accomplishment. To cast 250 castings on one runner is a feat which is, to say the least, not common. Some years ago the firm who have made this (Messrs. T. H. Pickles & Sons, Mytholmroyd) adopted for their small moulding machine and bench moulders a box 10½ in. square, 3½ in. deep, with rounded corners, but with two lugs or handles in place of one. Ordinary box pins are fitted in the top handle and the pins go through holes drilled in the bottom handle. The boxes are machined on both joints, thereby assuring a good fit. For castings that have a flat surface and are not deeper than 2 in., these boxes can be built one on top of another, the bottom part of one mould serving as the top part of that underneath it, the runner or down gate going right through to the bottom box. By this means a great deal of floor space is saved, and no time is lost in ramming unnecessary boxes, as every box contains a complete mould, with the exception of the top one which contains the scoop runner for receiving the metal.

Until recently no more than six boxes built up had been so cast, but to ascertain how far the principle could be applied, 25 boxes of complete moulds were made and, as the illustration shows, were cast successfully. The casting is a small table block weighing about 2 lbs. The order was for 250 from this pattern, so a plate pattern was made containing ten, and was then mounted on a turnover machine. No trouble was experienced in making the mould, but it was feared that metal dropping such a height

250 Castings Poured from One Runner.

would burst its way out through the joints of the bottom boxes. Quite the reverse actually happened. The moulds were poured from the top by a crane ladle, and when the castings were got out from the moulds a surprise awaited the experimenters; the bottom box was the only mould that was short run, and no reason can be adduced except that the pressure of air sent there by the fall of metal, offered such a resistance as to prevent it from entering the mould.

By the system of moulding here described fully 50 per cent. of floor space is saved, though for ordinary work eight to ten boxes high, or just sufficient to hold one shank full of metal, is the best number to adapt. Time is also saved in getting the castings out after being cast because there is only one box part instead of two.

A Method of Preparing Sections of Fractures of Steel for Microscopic Examination.*

By Alfred Campion, F.I.C. (Professor of Metallurgy in the Royal Technical College, Glasgow), and John M. Ferguson, A.R.T.C. (Glasgow).

In investigations relating to the breakdown of metals under stresses, however they may be applied, it is now recognised that an examination of the fracture, or of a section through the fracture, is often of the greatest importance. In many cases it is necessary to examine a section cut through the fracture of the material, in order to determine the manner in which rupture has taken place, before deciding upon the suitability or otherwise of material for a particular purpose.

FIG. 1.—POLISHED BUT UNETCHED. SHOWING JUNCTIONS BETWEEN STEEL AND ALLOY. MAGNIFIED 220 DIAMETERS.
(Reduced one-third in reproduction.)

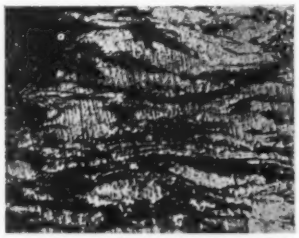


FIG. 2.—SECTION THROUGH TENSILE FRACTURE OF STEEL PLATE TEST-PIECE. MAGNIFIED 220 DIAMETERS.
(Reduced one-third in reproduction.)

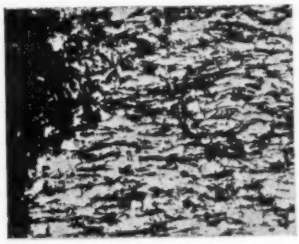


FIG. 3.—SECTION THROUGH FRACTURE OF TENSILE IMPACT TEST-PIECE. MAGNIFIED 220 DIAM.
(Reduced one-third in reproduction.)

As is well known, steel that has shown excellent results as regards tenacity and ductility in an ordinary static test, frequently fails under a load much below the maximum stress, or indeed the yield stress of the metal as shown by the usual tensile test; such material under impact or dynamic stress breaks suddenly, and appears to be very brittle. In such cases an examination of a section through the fracture often reveals the reason for such apparently extraordinary behaviour of the material.

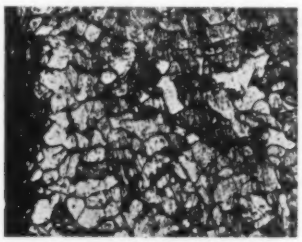


FIG. 4.—SECTION THROUGH FRACTURE OF REPEATED IMPACT (STANTON) TEST-PIECE. MAGNIFIED 220 DIAMETERS.
(Reduced one-third in reproduction.)

The preparation of sections of fractures for microscopical examination, especially of soft and ductile materials, presents considerable difficulty, as during the polishing operations the edges of the fracture become more or less rounded or worn away, and the true nature of the fracture is not discernible. In order to overcome this difficulty, Rosenhain employed an ingenious method of embedding the fracture in copper, and then cutting through the copper and steel in the desired direction, much in the same way that the biologist embeds his specimens in wax before sectioning. This method of depositing copper (or iron) electrolytically gives excellent results, and is quite satisfactory where comparatively few specimens have to be examined, or where no great hurry is necessary. It requires, however, strict attention to details, and it takes a considerable time to obtain a deposit one-eighth of an inch in thickness. There are many occasions when an examination of a section through a fractured test-piece would be of immense value, provided that it could be made easily and quickly.

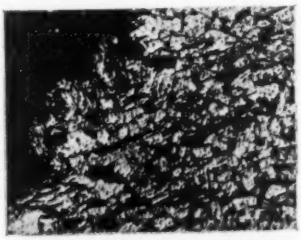


FIG. 5.—SECTION THROUGH FRACTURE OF REPEATED BENDING (SANKEY) TEST-PIECE. MAGNIFIED 220 DIAMETERS.
(Reduced one-third in reproduction.)

The authors recently had occasion to examine a very large number of fractures of static and impact tensile and other test-pieces. The time at their disposal was, however, too short to allow of their being

* Presented before the Autumn Meeting of the Iron and Steel Institute.

prepared by the Rosenhain method of electrolytically depositing copper or iron, and they were led to consider the possibility of other methods. It occurred to one of them that it might be possible to cast an easily fusible alloy around the fractured end of the test-bar and then section and polish.

The conditions to be satisfied appeared to be :— (1) The alloy must be of such a nature that it would readily penetrate into and fill up the minute fissures in the fracture. (2) The alloy must be sufficiently hard and strong to support the edges of the fracture during polishing. (3) The alloy must melt at a low temperature, so that no alteration of the structure of the material would be produced. (4) The alloy must adhere closely and strongly to the specimen, and not be torn away from it during operations of grinding and polishing. (5) The alloy must exert no chemical or other action on the edges of the specimen. (6) The alloy must be of such a nature that the edges of the fracture would show up sharply and clearly even after fairly strong etching.

Experiments were carried out with a number of alloys, and eventually two were found that fulfilled the above conditions in a marked degree. The composition of the alloys was as follows :—

	Alloy A.	Alloy B.
Bismuth	50 parts	50 parts
Lead	30 ,,	30 ,,
Tin	25 ,,	10 ,,
Zinc	3 ,,	—
Cadmium	—	10 ,,

Both alloys melt at temperatures below the boiling point of water, the melting point of B being about 25 deg. C. less than that of A. As a result of a large number of trials the alloy A was found to be the better for general work. The method adopted in preparing the sections was as follows :—

The fractured test-piece was dipped momentarily in hydrochloric acid of 1.1 specific gravity, and then in a solution of chloride of zinc (the ordinary "killed spirits" of the tinman) prepared by adding zinc to strong hydrochloric acid until no further action takes place, and then diluting with an equal volume of water. The end of the specimen was then plunged into a quantity of the alloy at such a temperature as just to keep it molten, and contained in a small, deep, narrow mould or crucible. The cold specimen usually somewhat chilled the alloy and caused partial solidification. It was therefore found advisable to remelt the alloy by gently warming the mould or crucible so as to allow of the escape of any air which might have been trapped, and also to ensure perfect adherence between the alloy and the steel. The latter being lighter than the alloy, the specimen must be weighted or held down in the molten alloy to the necessary depth until solidification takes place.

When cold, sections may be cut in any desired direction by means of a fine saw. Polishing can then be carried out in the usual manner.

A few micrographs of fractures prepared by this method are given in order to show the results obtained. Fig. 1 shows a section of a tensile impact fracture of soft steel embedded in the alloy, polished, but unetched. It shows the junction of steel and alloy. Figs. 2, 3, 4, and 5 are micrographs of etched sections of static tensile, impact tensile, repeated transverse impact (Stanton), and repeated bending (Sankey) test-pieces respectively.

The authors claim no advantage for this method over the Rosenhain method of deposition, except that it is very much quicker. A section may be prepared and a photograph obtained in about thirty minutes.

Correspondence.

Blast Quantity and Pressure in Cupola Working.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I was somewhat disappointed to find that Mr. Cook in his letter in your last issue had not given any particulars of the tuyeres and the shape of the brickwork which were employed in the cupolas upon which he carried out his tests, as this information would have been not only interesting but most useful. As Mr. Cook has confined himself to remarks upon the method of testing the volume of air which was adopted in the experiments carried out by my firm, I also will first deal with this.

In my recent letter to your columns, I should have, perhaps, mentioned that as the firm with which I am connected is engaged in the manufacture of blowers of all types as well as cupolas, numerous experiments have been carried out during the past few years to ascertain the correct volume of air delivered by these machines. No pains have been spared in this respect, and the co-efficients governing the flow of air through thin plate orifices, have been calibrated by actual deliveries of air into a gasometer installed for the purpose.

In the tests to which I refer, the machines used for delivering the air to the cupolas were manufactured by my firm and in every case volume and pressure curves were plotted while the machine was on the test plate, so that when delivering air to the cupolas, as well as the reading taken from the thin-edged orifice arranged on the suction—as described in my previous letter—the volume thus obtained was corroborated by referring to the curve corresponding to the revolutions of the machine and the pressure at which the air was delivered. I admit that the statement regarding leakage made by Mr. Cook is perfectly correct, and great care had to be taken to see that none took place during the tests.

In Mr. Cook's original Paper, he deduces from his tests the axiom that in order to obtain from a cupola the maximum possible rate of successful output, the product of the square root of the pressure and the quantity of blast in lbs. per minute, divided by the diameter of melting zone in feet must be equal to a certain constant. This, at its best, can only be considered as an empirical coincidence, probably only applicable to the two cupolas tested, and I am of the opinion that the air pressure is in no way a function in the good working of the cupola, but rather, a necessary evil, being merely the result of resistance within the cupola.

It being admitted that for the combustion of a certain quantity of coke, a certain quantity of oxygen is required and a certain velocity of air to give the necessary penetration of blast and to carry away the products of combustion, why should the pressure enter into the question at all? The only answer that can be given to this is that in order to obtain this quantity of oxygen and this velocity or air, a certain pressure must be obtained to overcome the resistance of the tuyeres and burden of the cupola. This brings me back to my original statement that the secret of successful cupola design lies in the correct proportioning of the tuyere area to the melting zone and the shape of the internal lining.

It is easy enough to recognise that a cupola of a given design when filled to the charging door with the usual proportion of charges of coke and iron, if supplied with a given volume of free air per minute, can only produce one pressure in the blast main except in so far as the sizes of the coke and

pieces of metal for making up the charges may vary and create a little extra or a little less resistance in the burden of the cupola. I submit, therefore, that the correct and only way to specify the blast quantity for a cupola is in so many cubic feet of free air per minute; and following the design which has been carried out for the cupola, the resulting pressure will be a pre-determined quantity. This method is also the correct one from another point of view, and that a very important one, viz., that all blowing machinery is catalogued and sold under this form of specification.

If Mr. Cook could explain how, with any given cupola, without altering the design of tuyeres or brickwork lining, or altering the height of the burden of the cupola which he himself admits has only one correct proportion to the diameter of the melting zone for efficient working, he could increase or decrease the "blast pressure as distinct from quantity," then perhaps his theory would hold good.

The velocity and penetration of the entering blast should most certainly be varied according to the class of iron to be produced, but if the correct volume of air to give the maximum melting capacity of the cupola is provided, this can only be done by altering the area of its tuyeres or the shape of its brickwork lining.

I append a few tests which perhaps you will be kind enough to allow to appear with this letter, as they may be of interest to some of your readers. These have been taken haphazard from the usual tests taken by my firm when cupolas are installed

Diameter of cupola at melting zone.	14 in.	16 in.	18 in.	20 in.	22 in.	27 in.	32 in.	36 in.
Total area of tuyeres in square inches ..	48.8	48.8	68.2	106	111	111	164	199
Area melting zone.	3.16	4.11	3.74	2.97	3.42	5.2	4.9	5.12
Area tuyeres.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Height from top row tuyeres to charging door	9 7	10 7	10 5	11 4½	12 2	12 7½	13 7	15 3
Total number of tuyeres and number of rows	9 tuyeres	in 3 rows of	3 in. in each case, top		row fitted	with shut-off valves for		regulation
Total cubic feet of free air per minute ..	818	1,315	1,880	2,550	3,150	3,720	3,900	4,160
Pressure of blast in air belt (in ozs.)	12	14	12	10½	11	12	10	12
Rate of metal melted per hour in tons ..	1.1	1.88	2.8	4.0	5.0	6	6.4	7
Total cubic feet of free air per ton melted ..	44,600	42,000	39,480	38,300	37,800	37,200	36,580	35,600

and are not to be considered as altogether comparable with one another, as the conditions under which they were taken varied considerably.

Yours, etc.,

Bradford, A. LIARDET.
September 11, 1913.

The Working of the Cupola.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—Having read with interest the article by Mr. J. G. Horner in the September issue, on "The Working of the Cupola," one naturally finds a number of statements upon which there is bound to be a difference of opinion. It is the reference to the drop bottom, as provided on modern cupolas when compared with the old solid bottom, which has especially arrested my attention. The solid-bottom furnace is familiar to all—together with its disadvantages in raking out, etc., to which your correspondent fully refers. May I therefore balance the comparison by indicating some of the peculiarities of its younger rival?

The drop bottom is put forward as a feature of cupolas of new design, and as a selling point it may be an undoubted acquisition. The simplicity of the whole arrangement when seen in the show-room or in diagrammatic form, certainly takes the eye. It is after operating the drop bottom for a period that the system appears to be not quite perfect. The dropping of the hinged doors is not satisfactory, bolts are usually immovably jammed at the crucial moment. The alternative method of propping up the doors by means of a bar, the latter being felled by a more or less well-directed piece of pig-iron thrown by one of the furnacemen (who incidentally gets out of the danger zone of splashing metal and slag in the shortest possible time), does not impress one as at all satisfactory.

Again, when all the contents do not fall—as is often the case—there is much more difficulty in clearing the obstinate portion hanging to the sides in the latter type, only the tuyers being available for the introduction of a bar; whilst the open front through which the contents are drawn in the solid-bottom furnace provides much better facilities for such an operation.

Then take the making up of the bottom; the old type will require a surface repair, perhaps every blow. The drop-bottom furnace wants a new bottom every blow. This means time, sand, and the introduction of considerable moisture, which has to find its way out upwards, thus introducing an element for trouble at the tapping hole, should the first metal falling on the hearth strike this dampness and solidify. In the desire to be "modern," there is perhaps a tendency to discard proved methods of early origin too quickly, without due thought being given to details. It is only after getting the new and having to live with it that some of the virtues of the earlier type become apparent.

One advantage of the drop bottom has, however, been omitted, *i.e.*, it may readily be converted into the earlier form again! It would be interesting to know how many of the drop-bottom cupolas which have been installed in this country during the last 20 years are either now out of use or re-converted to the old form; also how many solid-bottom cupolas have been installed during that time after experience with the drop bottom.

Yours, etc.,

113, Ellesmere Road, H. SHERBURN.
Lower Walton, Warrington.

Tests of Cupola Gases.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I have been much interested in the article in the September issue of your paper, entitled "Tests of Cupola Gases and Temperatures." Whilst the recommendations of the author, if carefully carried out, would undoubtedly reduce the loss of iron due to oxidation; yet it seems to me that the saving would not be so great as at first sight might appear on reading this article. I allude to the fact, that the molten iron in its passage to the hearth of the cupola must pass through the zone opposite to the tuyeres, where, the author admits, oxygen is present, and it would appear that a certain amount of oxidation must therefore take place during this passage.

Of course as the experimental cupola was not charged with either iron or flux, this point was not brought out by the experiments, but I think it would be interesting to hear something on this point from those qualified to speak.

Yours, etc.,

J. BLENCOWE HOWARD.

Colchester.
September 26, 1913.

Foundry Plant and Equipment.

Modern Geared Crane Ladles.

We illustrate herewith two improved designs of foundry ladles by Messrs. Thwaites Bros., Limited, Vulcan Iron Works, Bradford. Fig. 1 shows a lip-pouring ladle with lifting link astride of beam. This design embodies several features which are distinct improvements on older types. The uprights and cross-beams are formed entirely of rolled channel sections, which form a very rigid structure, so that the ladle body always turns freely on its trunnions, which are carried in machined bearings riveted to the channel uprights. These trunnions are riveted to the body before being turned in the lathe. Special attention is paid to accurate balancing. The gearing, which consists of a worm and wheel, is carried in a machined cast-iron bracket, attached by bolts to one of the uprights, in such a way that it cannot become displaced as in some other designs. The whole gearing is neatly encased in a sheet-iron cover, so that no splashes of metal can get into the teeth of the gear while pouring. All rivets on the interior of the ladles are flattened. All ladles are designed to have ample capacity for the rated quantity of metal, after allowing for thickness of lining and margin to avoid spilling during transport. The gearing is standardised to ensure interchangeability of parts.

Fig. 2 shows a design which follows the same lines as Fig. 1, with the addition of a stopper rod and side lever for controlling the flow of metal through a cast-steel nozzle riveted to the base. These ladles are made in all sizes from 1 ton upwards.

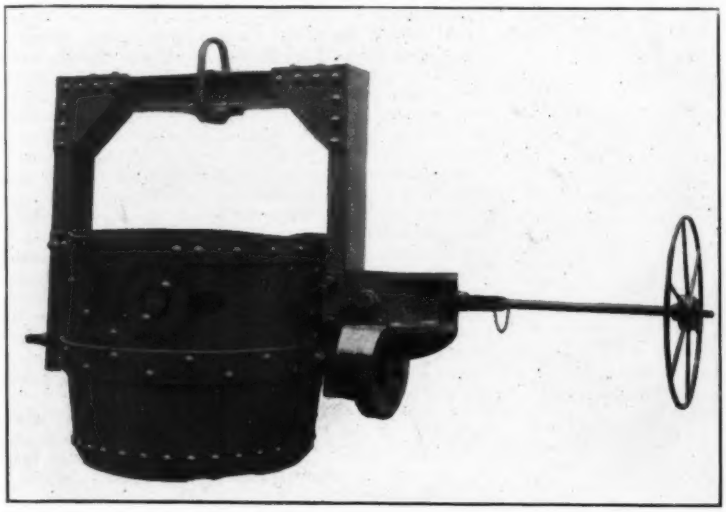


FIG. 1.—GEARED CRANE LADLE, LIP POURING.

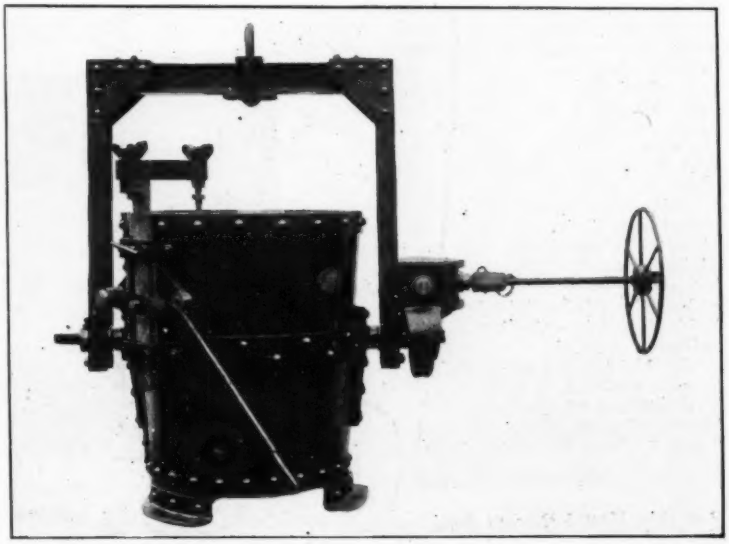


FIG. 2.—GEARED CRANE LADLE, BOTTOM POURING.

The "Leeds" Portable Mould and Ladle Drier.

The mould and ladle drier shown in the accompanying illustrations is made in two types, viz., type A, self-contained, with electric motor and fan; and type B, for pipe connection to blast. The stove is of the open-ashpit type with an induced draught; the fire can be made up at any time without interfering with the blast pipe, on which no valves are necessary. The fire-box is ganister-lined and being circular the lining can very easily be re-made. The drier is provided with a hinged lid for charging; the grate also is hinged and can be dropped after use for removal of any unburnt coke. The stove has a bail handle for lifting with the crane when convenient, and two lugs are provided on the sides

for porter bars, as the apparatus can easily be moved by two men.

A reversible valve is fitted and the hot blast can be delivered either vertically downwards or horizontally, as illustrated. A large volume of hot air is blown through the mould, and by this means it is claimed that the moisture is quickly dispersed and moulds of any shape are dried evenly and uniformly. Owing to the induced draught, no cinders, grit or dirt are blown into the moulds. The stove when fully charged takes only about 20 lbs. of coke and requires no attention. In the self-contained type no pipes are required for carrying the blast to the stoves, it being merely necessary to connect the wires to the nearest electric socket, when the stove can be started from cold in ten minutes. For ladle drying a plate is placed over the ladle with a hole four inches diameter in the centre, and the plate raised slightly from the ladle to allow egress of the hot air. The drier is placed over the hole, and as there is a slight increase of pressure inside the ladle, the hot air is distributed uniformly over the surface to be dried.

FIG. 1.—THE "LEEDS" MOULD DRIER, SELF-CONTAINED TYPE.

Fig. 1 shows the self-contained apparatus, type A, and Fig. 2 type B, with downward blast outlet. The makers of this drier are Messrs. Horace P. Marshall & Company, 6 and 7, Cross Fountaine Street, Leeds.

Portable Mould-Drying Set.

In the description of the portable mould-drying set given on page 609 of our last issue, it should have been stated that the mould-drier employed in the set is the well-known apparatus made by Messrs. Tilghman's Patent Sand Blast Company, Limited, Broadheath, near Manchester.

Water Cooling of Open-Hearth Furnaces.

That the practice of water-cooling the ports, etc., of open-hearth furnaces is making some progress in this country is evidenced by the accompanying sectional views of the port end of a furnace now being built for a leading British firm, and which is equipped, as will be noted, with the Knox water-cooled port-block frame. Briefly the function of this port block is to take care of the brickwork at the nose of the port, so effectively cooling it that there is no cutting away, and the point of combustion remains in the same position as originally fixed.

It is obvious that the repairs to open-hearth ports should be largely eliminated by the introduction of such a device, and that the life of the furnace should be considerably lengthened, the time from tap to tap being decreased and the output of the furnace largely increased. Seeing that this port block is covered with brickwork, it requires considerably less water than devices that are wholly exposed to the incoming gases, or the heat of the furnace. Moreover, the water is used over and over again, by means of the circulating system devised for use with the appliance.

The furnace shown is also fitted with the Knox water-cooled door frames, by the use of which practically the whole of the furnace front is cooled, tending to the greater comfort and higher efficiency of the furnacemen.

We understand that the United States Steel Corporation now adopts the Knox devices as standard in their furnaces; the seven 100-ton furnaces being built at their Minnesota Works are to be fitted entirely with the above devices.

Rust-Proof Coating for Iron or Steel.

A new rust-proof coating, described in a contemporary, is a paint that is applied to the surface of the article to be coated and then baked. The ingredients are:—Linseed oil, 25 parts; calcium

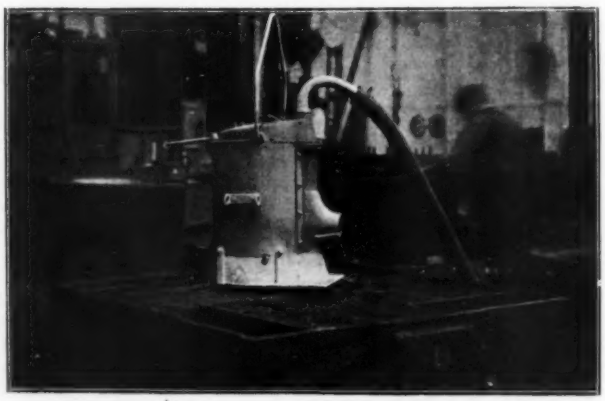
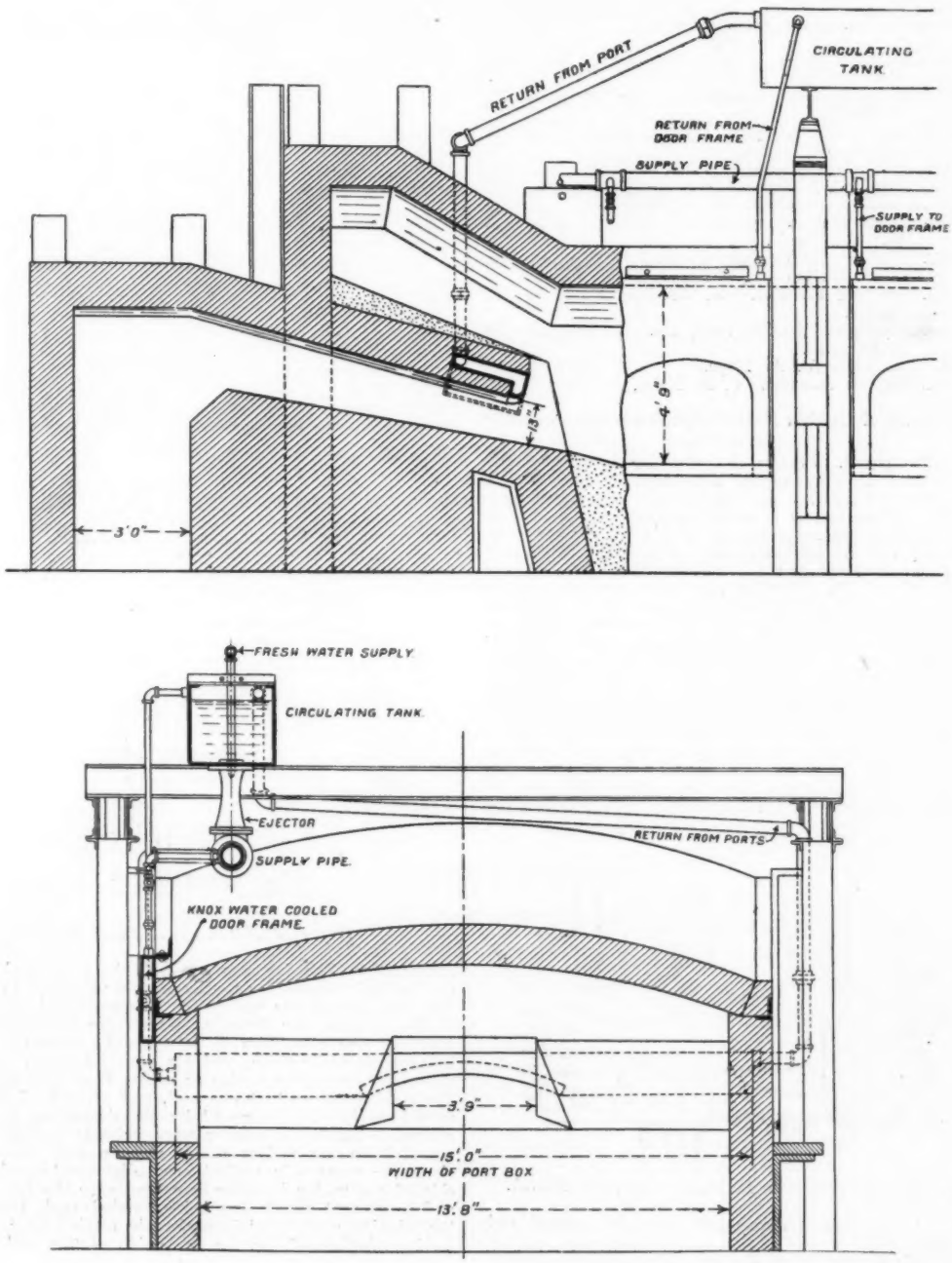


FIG. 2.—THE "LEEDS" MOULD DRIER, WITH DOWNWARD BLAST OUTLET.

resinate, 36 parts; manganese borate, ½ part; lead acetate, 1 part; naphtha, 37½ parts; artificial graphite, 25 parts. These are mixed and applied to the metal by brushing or dipping or any other method. The article is then baked at 300 degs. F. for 1 hour and 40 minutes. The coating is stated to be highly lustrous and resistant to corrosion. No other form of graphite gives satisfactory results.

D



OPEN-HEARTH FURNACE PORT END FITTED WITH KNOX WATER-COOLED PORTS.

Inventions.

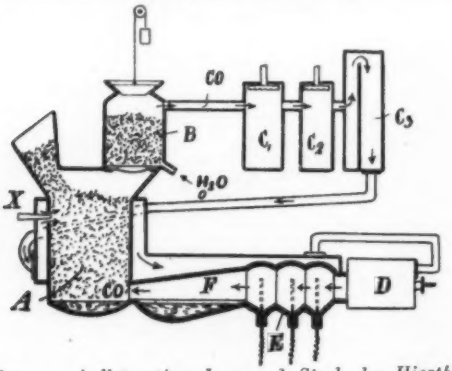
Applications for Patents.

An Asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

18,306. Firing furnaces with gasified liquid fuel. J. Sackett and S. A. Cobbett.
18,510.*Process of heating and moulding metals. F. H. de Lostalot.
18,607. Cranes for stripping and handling ingots and moulds. E. Crowe.
18,643. Local hardening of iron and malleable iron castings. C. L. Sumpter.
19,353.*Casting machines. C. A. Campbell.
19,402. Production of castings by means of dies. G. W. Wardle.
19,982. Machine for cutting off metal bars, tubes, etc. C. H. Clifton and Clifton & Baird, Limited.
20,101. Gas-fired furnaces. H. E. Collins and W. F. Collins.
20,161. Drying and heating sand, etc. T. Coleman and F. Coleman.
20,164. Furnaces. J. A. Hope.
20,371.*Electric furnaces. C. A. Keller.

Abstracts of British Patent Specifications recently accepted.

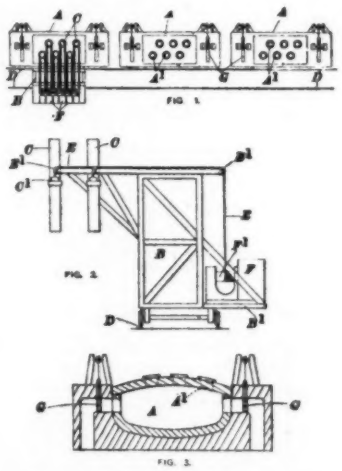
16,275 (1912). *Process of Extracting Iron and Steel.* A Hiorth, 13, Josefinegate, Christiania, Norway.—A is the reduction shaft, B the gas generator, C_1, C_2, C_3, gas washing apparatus, D is a fan or other blast device, E electric flame-arc furnaces, and F a steel furnace, constructed like a fore-hearth and arranged between the flame-arc furnaces and the shaft-furnace. The gases employed for the reduction are produced from coal in the generator B, (placed as near as possible to A). The pure gases are driven by the fan D through the furnaces E, in which they are heated to the desired extent, and from thence they are conducted through the steel furnace or the fore-hearth F arranged just in front of the shaft. In this fore-hearth in which the finishing treatment of the iron coming from the shaft is wholly or partly performed, the hot gases pass across the surface of the molten iron thereby supplying it with the heat necessary for the steel making treatment. By supplying air the temperature above steel bath may be further raised. From the fore-hearth the gas enters the



Process of Extracting Iron and Steel, by Hiorth.

shaft A in which it causes the ore to be reduced and the iron to be molten down, the carbonic acid thereby produced passing from the top of the shaft directly into the generator B. At a suitable point the gas (after having passed through the blower or fan) is drawn out to supply the extra heat from above to the charge, air or oxygen being supplied at X together with this gas. The shaft A is charged with iron ore (and it may be a small quantity of coal for carburation up to about 1 per cent., and for eliminating the action of the carbonic acid that may be carried along with the reduction gases). Otherwise the carburation is effected by blowing carbon powder (or crude oil) into the gas in front of the shaft, that is, into the steel furnace. When so conducting the process as to reduce off almost pure iron, a small carburation shaft is advantageously provided in front of the ore shaft thereby also obtaining a supply of carbon for carburation purposes and compensation of the action of the carbonic acid and aqueous vapour contents of the gas. Around the shaft furnace A and the upper portion of the fore-hearth F and the flame-arc furnaces E is arranged a jacket through which pass the gases coming from the washing apparatus C_1, C_2, C_3, the gases being thereby preheated before being introduced into the furnaces E through the fan D.

2,709 (1912). *Metallurgical Furnaces.* S. Cornthwaite, Jössingfjord, Sogndal i Dalene, Norway.—Fig. 1 is a diagrammatic plan of three furnaces arranged to be heated according to the invention; Fig. 2 is an end elevation on a larger scale of an electrode trolley or carrier; Fig. 3 is a longitudinal section through one furnace Two or more open-hearth furnaces A are provided with the usual air and gas ports, and with regenerative chambers for the air and gas, the arrangements being such that any of the furnaces A may be heated by gas. A trolley B is provided carrying electrodes C above the furnaces for heating any of them



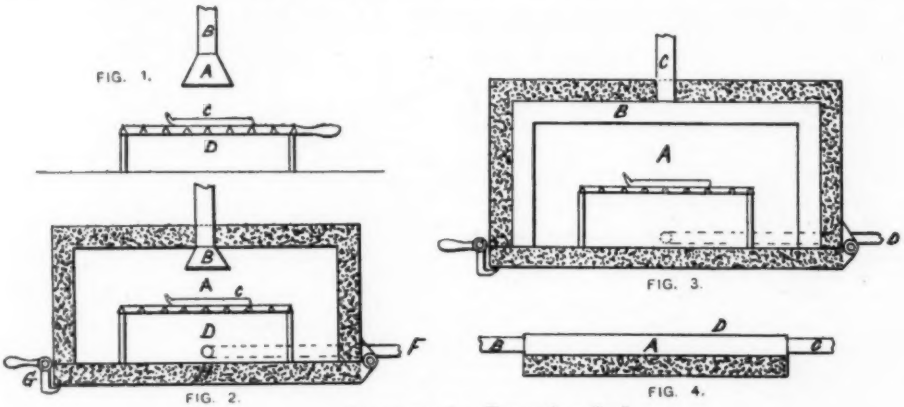
Improved Metallurgical Furnace.

electrically. The furnaces are side by side, and the trolley B is mounted on rails D laid adjacent to the furnaces, so that the trolley can be moved to bring the electrodes over any furnace. Means are provided for inserting the electrodes C into the furnaces through holes A^1 in their roofs, and for removing them. Such means may comprise chains or cables E secured to the electrode holders C^1 at one end, and capable of being wound on suitable drums F^1 by electric motors F, the chains or cables E passing over suitable pulleys E^1 mounted on the trolley B. It will be seen that the electrodes necessarily project some distance beyond the side of the trolley in order to extend over the furnaces and to prevent the trolley being overbalanced, thereby the winding gear F, F^1 is preferably carried by a projecting platform B on the other side of the trolley.

27,838 (1912). *High Speed Tool Steel.* The Stahlwerk Becker Aktiengesellschaft, Krefeld-Willich, Germany.—According to the invention, the improved high speed tool steel is produced by the addition of cobalt to the known compositions hitherto employed in the production of high speed tool steels, preferably up to 15 per cent.

of cobalt being employed. As is well known, these high speed tool steels comprise, essentially, steel, tungsten and chromium, with or without either or both of the metals vanadium and molybdenum. The following example is given of the production of a high speed tool steel of exceptional quality :—An alloy of steel containing about 0.70 per cent. carbon, 5 per cent. chromium, 18 per cent. tungsten, 1 per cent. vanadium, 0.75 per cent. molybdenum, and about 4 per cent. cobalt. It will, however, be understood that either vanadium or molybdenum or both of these metals may be omitted if desired.

17,014 (1912). *Tempering Steel.* F. O. Bynoe, 51, Myrtle Road, Acton, London, W.; and H. Edwards, 56, Marlborough Hill, Harrow, Middlesex.—Fig. 1 represents the method by which the tempering is accomplished in the open atmosphere. A nozzle or spray A is fixed above a grid or support D, upon which is placed any article C that is required to be tempered. The superheated steam enters the nozzle or spray A through the tube B, and impinges on the article C, which is placed on the grid or support D. Fig. 2 represents the method by which the tempering is accomplished in an enclosed chamber A. The superheated steam enters the chamber A by way of a nozzle or spray B, and comes in contact with the article C that is required to be tempered, and which is placed on the grid or support D. The steam afterwards exhausts through the pipe F. H is a hinged bottom door carrying the grid or support D. A catch G holds the door H in position. The door is released either automatically or by hand so soon as the



Apparatus for Tempering Steel.

required temperature is reached, and the article C being tempered then drops into a tank containing any liquid cooler. Fig. 3 represents the method by which the tempering is accomplished in an inner tempering chamber A, which chamber is surrounded by a hollow jacket B. The superheated steam ends and flows through the hollow jacket B by way of a tube C, and the tempering chamber is thereby heated to the required temperature, and the steam exhausts through the pipe D. The articles to be tempered are placed in the chamber as described in Fig. 2, and dropped into a tank containing any liquid cooler as described. Fig. 4 represents the method by which the tempering is accomplished by providing a shallow hollow chamber A. The superheated steam is caused to flow into the chamber A by way of a tube B, and the upper outer enclosing surface D of the chamber is thereby heated to the required temperature and the steam exhausts through the pipe C or other suitable outlet. The article to be tempered is placed in the surface D.

25,974, (1912). *Making Dephosphorised High Grade Pig-iron.* P. L. T. Héroult, 149, Broadway, New York, U.S.A.—Ordinary pig-iron is first made from phosphoric ore in a blast furnace, and transferred in a molten state to an electric furnace, and there treated with proper slags and regulation of temperature and in a non-oxidising atmosphere, so as to dephosphorise to the desired extent. When the molten pig-iron is first introduced into the electric furnace a basic slag, containing as much lime as possible, and containing also some oxide of iron is applied to the bath, and the current is regulated so as to maintain a low temperature, just sufficient to keep the slag molten and to cause the same to combine with the silicon and phosphorus in the bath, leaving the carbon content of the metal practically unchanged, or only slightly reduced. When the dephosphorisation has proceeded to the desired extent, the first slag is removed and a second slag is substituted consisting for example of lime and fluorspar with coke dust added. This second slag is very basic and practically free from oxide of iron. The effect is to remove all, or practically all of the sulphur.

"F.T.J." Bookshelf.

The Practical Metallography of Iron and Steel.

By John S. G. Primrose, A.R.T.C., A.I.M.M. Manchester: The Scientific Publishing Company.

This is a concise and practical work on the science of metallography, and in the 126 pages occupied the essentials appear to be well presented in a form suitable for the iron and steel maker and user. The discussions of theoretical considerations have been made as brief and non-controversial as possible—a feature which will be appreciated by many practical men who have hitherto encountered only the more exhaustive works on the subject. The book is well illustrated, but we think it would have been better had the advertisements of instruments, etc., been collected at the end instead of being interspersed between the matter.

A NEW Diesel engine manufactory, it appears is to be laid down on the Clyde, the Fairfield Company and John Brown & Company being interested. With this new factory there will be three works in Glasgow devoted solely to the building of Diesel engines. Work is being pushed ahead on the new factory of the North British Diesel Company, at Jordonvale. It will, however, be a year or eighteen months before the shops are ready to execute work.

Trade Talk.

MESSRS. JOHN BRADLEY & COMPANY, Blakedown Ironworks, Kiddermister, are retiring from business.

S. RAWLINGS & SON, LIMITED, have removed their London office to 79½ Gracechurch Street, E.C.

KITSON & COMPANY, LIMITED, of Hunslet, Leeds, are making considerable extensions to their Airedale Foundry.

EDWIN COTTAM & COMPANY, LIMITED, steel founders and spring manufacturers, of Rotherham, have erected a new foundry at their works.

HARDY SELIGMANN, FRANCIS & COMPANY, LIMITED, metal merchants and agents, have removed to 92 and 94, Gracechurch Street, London, E.C.

MESSRS. WATSON & COOMBER, iron and tinplate merchants, have removed from 85, Paradise Street, Liverpool, to 10 and 12, Beckwith Street, Liverpool.

MESSRS. IRWIN & JONES, engineers' agents, have removed from 5, London Wall Buildings, London Wall, E.C., to London House, New London Street, E.C.

THE foundation stone of the new building of the Institute of Marine Engineers on Tower Hill is to be laid on Wednesday, October 29, by the Lord Mayor of London.

THE extensive iron works belonging to James Dunlop and Company, Limited, situated on the north bank of the Clyde, near Cambuslang, have been considerably damaged by fire.

MESSRS. PYNE, HUGHMAN & COMPANY, engineers, of Calcutta, have established a London branch at Bank Chambers, 329, High Holborn, W.C., under the charge of Mr. F. M. Short.

MR. R. PEREGRINE, of Rugby Road, Neath, has been appointed Welsh agent for Messrs. James Wilson & Sons, tube and edge-tool manufacturers, Coatbridge Works, Coatbridge.

AN outbreak of fire has occurred in the foundry department of the Hallside Works of the Steel Company of Scotland, Limited, at Cambuslang, but the damage was not serious.

THE business of the Mechanical Appliances Company, mill and engineers' furnishers, 12, Affleck Street, Aberdeen, has been acquired by Mr. James Kelman, formerly manager of the company.

THE STERLING TELEPHONE & ELECTRIC COMPANY, LIMITED, of 200, Upper Thames Street, London, E.C., are removing to more commodious premises at 210, 211, & 212, Tottenham Court Road, London, W.

MR. ROBERT BOOTH, of 110, Cannon Street, London, E.C., has taken over the representation in the United Kingdom and Colonies of Messrs. Paul Würth & Company, constructional engineers, of Luxemburg.

A SERIOUS fire occurred on September 7 at the engineering works of Robey & Company, Limited, at Lincoln. Fortunately the outbreak was confined to the moulding shop, or the loss would have been heavy.

MESSRS. J. IVOR JENKINS & COMPANY, metal and tinplate brokers, 9, Wind Street, Swansea, have acquired the business of Mr. Alfred Rohde, tinplate and metal merchant and agent, 2, Adelaide Chambers, Swansea.

THE LILLESHALL COMPANY, LIMITED, (engineering department), Oakengates, Shropshire, have appointed Messrs. I. J. David & Company, 7, Bute Crescent, Bute Docks, Cardiff, as their agents in the Swansea district.

MESSRS. ANDRE CITROEN & COMPANY, of 27, Queen Victoria Street, London, E.C., will in future trade as The Citroen Gear Company, Limited. This change will in no way affect the internal organisation of the business.

THE partnership heretofore subsisting between M. Palmer, the younger, and F. Palmer, carrying on business as engineers and machinists, at Chatteris, Cambridgeshire, under the style of M. and F. Palmer, has been dissolved.

MESSRS. JAMES ALEXANDER and JOHN REID have retired from the firm of Thomas Reid & Sons, engineers, Thread Street, Paisley, which will now be continued by Mr. Thomas Reid, who will discharge the liabilities of the dissolved firm.

A. A. JAMES, LIMITED, of the St. George's Works, West Bromwich, have recently made extensive alterations in their spring-making department, including the installation of the latest machines for producing all kinds of springs and spring washers.

MR. R. ST. GEORGE MOORE, has amalgamated his civil engineering practice with that of Mr. La Trobe-Bateman and Mr. J. R. Fox, and in future the business will be carried on as Fox, Moore, Bateman & Fox, 5, Victoria Street, Westminster, London, S.W.

BROTHERTON TUBES & CONDUITS, LIMITED, have removed their Manchester offices to 4, Carr Street, Blackfriars. The directors of the company recommend that the capital be written down from £65,000 to £13,000 by cancelling 15s. on each £1 share.

MESSRS. WHITLEY PARTNERS are building new offices and additional warehouse accommodation at their Hunslet Road Works, Leeds. The new building, which fronts on to Hunslet Road, will cover the whole of the space available for building adjacent to the works.

MR. S. N. BRAYSHAW, 2, Mulberry Street, Hulme, Manchester, is separating the furnace portion of his business from the other departments, and is removing the former to the works at Longsight, formerly occupied by the Vernon Engineering Company, Limited.

THE popularity of the "Robinson" superheater amongst locomotive engineers is evidenced by the fact that orders have recently been given by English, Scotch and Irish railways, in addition to South American and foreign lines. The orders cover upwards of 100 engines.

A BLUE BOOK issued by the Board of Trade shows that 219 settlements respecting the rates of wages, hours of labour and other conditions of service of men employed on the railways of Great Britain were effected during last year under the revised Railway Conciliation scheme.

MESSRS. S. PARSONS & COMPANY, engineers, Horton Ironworks, Beckside Road, Bradford, are putting up extensive premises at the corner of Vicar Lane and Bridge Street, Bradford, which they will open as weighing machinists and constructional and heating engineers.

MESSRS. F. B. NATHAN and F. S. ALLEN have established themselves in business at Queen Anne's Chambers, Westminster, London, S.W., as agents for the Kartret Engineering Company, Westminster, S.W., and the Wardle Engineering Company, Limited, 196, Deansgate, Manchester.

THE partnership heretofore subsisting between Messrs. S. S. Ready and E. B. Carless, 178, Aston Road, Birmingham, carrying on business as brassfounders, at 178, Aston Road, Birmingham, under the style of Ready & Son, has been dissolved. Ready & Sons, Limited, will in future carry on the business.

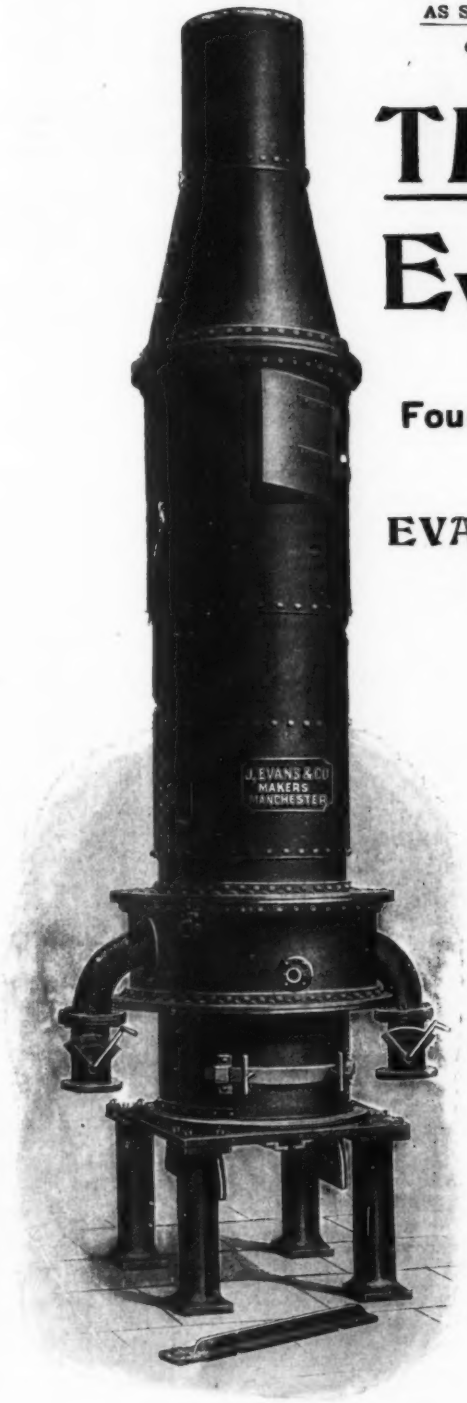
MESSRS. RUDOLF WOLFF, KREUGER & COMPANY, 147, Leadenhall Street, London, E.C., have established a branch in Hong Kong, with agents elsewhere in China, for the conducting of business with the Far East. The style and address of the firm is Rudolf Wolff & Kew, Limited, 14, Des Voeux Road, Hong Kong.

A MEETING of the members of the Ivorite Nickel Electro Foundry, Limited, will be held at 22, Basinghall Street, London, E.C., on Saturday, October 18, for the purpose of having an account laid before them showing the manner in which the winding-up of the company has been conducted and the property disposed of.

MARKHAM & COMPANY, LIMITED, of the Broad Oaks Ironworks, Chesterfield, are at present engaged upon an addition to their boiler-mounting shops. A large electrical crane has been bodily moved a short distance away to clear the site for the extensions, which follow upon the recent enlargement of the blacksmiths' and forge department.

HENRY BERRY & COMPANY, LIMITED, of Leeds, are making an extensive addition to the machine shop at their Croydon works. The new shop will be particularly well lighted, as it is to have an all glass roof and a glass side. It extends to the boundary of the company's property and will have a gateway entrance from Beza Street, Hunslet.

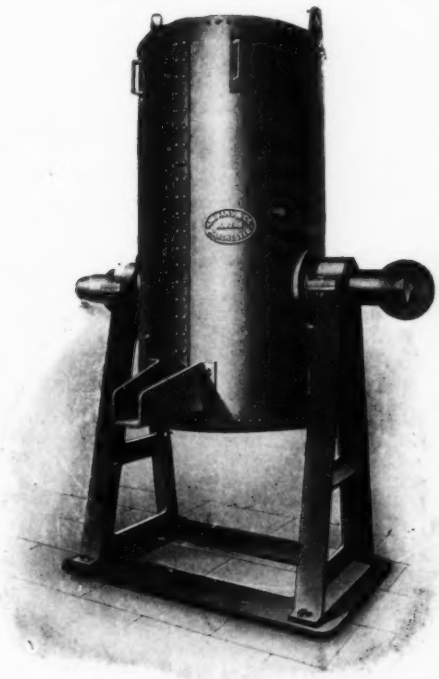
AS SUPPLIED TO THE ADMIRALTY, WAR OFFICE,
COLONIES, AND FOREIGN GOVERNMENTS.



THE Cupola.
Evans's Rapid.

Foundries Completely Furnished.

EVANS'S NEW CUPOLETTE
For Emergency Work.



James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Telegrams: "LADLES, MANCHESTER."

In future the meetings of the Newcastle and District Branch of the British Foundrymen's Association will be held in the Armstrong College. A series of lectures have been arranged to be delivered on Tuesday evenings in conjunction with the Armstrong College authorities on the principles of metallurgy. A laboratory course will be held in connection with these lectures.

Messrs. A. Heimsoth & O. Vollmer inform us that they have acquired the business of Messrs. Paul Schmidt & Desgraz, of Hanover, Germany, who have for some years made a speciality of open-hearth steel furnaces, re-heating furnaces, gas producers, etc. The business will be carried on exactly as before, but under the new title of the Heimsoth und Vollmer Gesellschaft.

The Electrical Engineering and Equipment Company, Limited, Bank Buildings, 109-111, New Oxford Street, London, W.C., have been appointed British and Colonial agents for the Ateliers des Constructions Electriques, of Charleroi, Belgium, manufacturers of A.C. and D.C. motors and generators, traction motors, electric cranes, centrifugal pumps, haulage and winding gears, etc.

Mr. Sherard Cowper-Coles has granted a license to the British Mannesmann Tube Company, Limited, for ferro-zincing and ironising boiler tubes to prevent corrosion and pitting; they are erecting a plant for this purpose at their works at Landore. As previously announced the British Mannesmann Tube Company, Limited, who have large works at Landore, contemplate opening extensive works at Trafford Park, Manchester.

Notice is given that, at the expiration of three months, the names of the undermentioned Companies will be struck off the Register of Joint Stock Companies, and the companies will be dissolved:—Brettell, Wanklin & Company, Limited; British Electro Metallurgical Products Company, Limited: Chas. H. Hampshire, Limited; Finsbury Engineering Works, Limited; Hadfield's Limited; Whittington Welding Company, Limited.

Negotiations have been completed between the British Aluminium Company, Limited, and the Burntisland Town Council in regard to facilities for the establishment of a manufactory close to the town. The ground selected is chiefly on Gedsmill estate, and extends to forty acres. Closely adjoining the main line of the North British Railway, and within easy access to the docks, the eligibility of the site is unquestioned, and the town authorities have promised water and drainage on generous terms.

The Sectional Committee of the Engineering Standards Committee on sections and tests for material used in the construction of ships and their machinery, having had under consideration certain proposals with regard to the screwing of marine boiler stays, which were submitted by the Consultative Committee of Shipbuilders and Engineers appointed to confer with the Marine Department of the Board of Trade, make the following recommendations:—(1) That the Whitworth form of thread be used; (2) that nine threads per inch be used for all screwed stays above 1¼ inches diameter; (3) that six threads per inch be used for longitudinal stays above 2 inches diameter having nuts on both sides of the plate. This report was approved by the Main Committee.

In the case of the Manchester and County Bank *v.* Falcon Ironworks, Limited, at the Lancashire Chancery Court, on September 23, Mr. Abbott said this was a debenture-holders' action, and he appeared on a motion for the appointment of a receiver and manager. He understood the application he made was not opposed. The Company was incorporated in 1898 to carry on the business of electrical engineers, boiler-makers, and iron-founders, at Oldham. This was counsel said, a case of jeopardy. Actions had been started against the Company, there was no defence to them, and there was grave risk of executions being levied. Mr. Eastwood, for the Company, agreed to the appointment of a receiver, and the Court accordingly appointed Mr. H. Bayley (Messrs. Stowell, Bayley, and Company, chartered accountants, Manchester) receiver, with liberty to act at once, the motion to be turned into a motion for judgment, with the usual debenture-holders' decree.

Lead, Limited, have acquired from Mr. Sherard Cowper-Coles the sole right for the coating of iron and steel with lead by an electrolytic process. Lead by this process can, it is claimed, be deposited up to a thickness of ¼th of an inch economically. A plant has been erected in London for the coating of sash bars for window frames and for metallic glazing for roofs. The process also enables brass, copper and other metals to be coated with lead. Steel sheets coated with lead by this process are much smoother than the ordinary terne plate; there is no reduction in tensile strength or ductility. The process can also be applied to the coating of earthenware and wood, and the protection of ornamental ironwork. The process is rapid and the cost claimed is low. For an equal weight of metal, it is stated to be cheaper than hot galvanizing. The following is given as the cost of depositing lead in varying thicknesses up to 6/100 inch, the cost of electric current being taken at 1d. per kilowatt hour, and lead at £22 per ton:—

Thickness.	Weight of Lead, Oz. per Super foot.	Cost of Lead per Super Foot.	Cost of Electricity per Super Foot.	Total cost per Super Foot for Lead and Electric Current.
Inch.	oz.	d.	d.	d.
.001	0.949	.139	.0069	.146
.005	4.745	.696	.035	.731
.010	9.490	1.392	.069	1.461
.015	14.235	2.088	.104	2.192
.020	18.980	2.784	.138	2.922
0.25	23.725	3.480	.173	3.653
0.30	28.470	4.176	.207	4.383
.035	33.215	4.870	.241	5.11₂
.040	37.960	5.568	.276	5.844
.045	42.705	6.270	.311	6.581
.050	47.450	6.960	.345	7.350
.055	52.195	7.655	.374	8.070
.060	56.940	8.352	.414	8.766

Northampton Polytechnic Institute.

The volume of announcements and particulars of educational courses of the Northampton Polytechnic Institute, St. John Street, London, E.C., has been issued for the session 1913-14. During the past year the equipment has been extended in various directions. Among the more important items may be mentioned in the Mechanical Engineering Department, a complete outfit for the micro-photographic examination of engineering materials and additional machine tools. In the Electrical Engineering Department the laboratory equipment for radio-telegraphy has been considerably extended, and additions have been made to the equipment of generators, measuring instruments and photometers. In the Metallurgical Department the equipment of electric and gas furnaces and pyrometers has been extended and a modern metallurgical microscope has been added. In all the departments other and sometimes important additions have been made.

The courses of the Engineering Day College are being continued with certain minor developments. In the evening classes in engineering important departures have been made by the introduction, as part of the regular courses, of short courses of lectures by specialists in their various subjects. Again, in the mechanical engineering department the main course of lectures upon Aeronautics is taken by three specialist lecturers. In connection with these courses there are full courses in drawing office, laboratory and mathematical work for all students who desire to study the important subject of Aeronautics thoroughly. Special classes in Submarine Cable Work for the employés of the various Cable Companies who have their headquarters in London are to be held under the direction of Mr. J. H. Stephens, of the Eastern Telegraph Company.

There are other minor new developments too numerous to specify in all departments, including Mechanical and Electrical Engineering, Artistic Crafts, etc.

IMPORTANT TO IRONFOUNDERS.

MOULDING—
—MACHINES

FOR REPETITION FOUNDRY WORK.

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HAND PRESS MACHINE

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HAND RAMMING MACHINE

where a Deep Lift is required. Can be Operated by

UNSKILLED LABOUR.

MOST EFFICIENT AND ECONOMICAL IN USE.

Also Makers - - of - - ROOTS' "ACME" BLOWERS.

FULL PARTICULARS FROM—

Samuelson & Co., Ltd., Banbury,

ENGLAND.

SEE OUR ADVERTISEMENT EVERY ALTERNATE MONTH.

Personal.

MR. T. W. WARD, of T. W. Ward, Limited, was installed Master Cutler of Sheffield last month.

MR. F. HEPPENSTALL, of Johnson & Phillips, Limited, has sailed for Canada on the firm's business.

MR. W. H. ROBINSON has been appointed manager to Brown Bayley's Steel Works, Limited, Sheffield.

THE late Mr. A. Jeffrey, of Messrs. A. Jeffrey & Company, left personal estate of the value of £6,960.

THE late Mr. Thomas Croft, engineer and agricultural implement maker, and a member of the firm of Croft & Ewan, left estate of the value of £7,470.

THE late Mr. P. Donaldson, of James Watson & Company, Limited, and James Dunlop & Company, Limited, has left estate provisionally valued for probate at £52,252.

THE late Mr. S. Beal, of Edward Deane and Beal, Limited, engineers and brassfounders, left estate of the gross value of £22,101, of which the net personalty has been sworn at £14,971.

THE late Mr. J. G. Muir, associated with the Anderston Foundry Company, Limited, Glasgow, left estate of the gross value of £68,782, of which the net personalty has been sworn at £59,595.

THE late Mr. E. B. Chittenden, of New Barnes, West Malling, Kent, a director of Aveling & Porter, Limited, engineers, left estate of the gross value of £43,747, of which £36,690 is net personalty.

THE result of the final ballot for the appointment to the general secretaryship of the Amalgamated Society of Engineers is that Mr. Robert Young has been successful by 22,091 votes against 18,597 for the acting official, Mr. Jenkin Jones.

MR. J. A. S. HANBURY, who has represented H. R. Merton & Company, Limited, in Birmingham for 32 years, and is now going to Australia, has been the recipient of a handsome presentation from his numerous friends in Birmingham.

MR. J. M'FARLANE, who has been associated with the Lanarkshire Steel Works since their inception, has now resigned his position as general works manager. The new general works manager is Mr. Andrew Gray, who has been in the company's service for some years.

MR. W. J. BROOKE, departmental manager at the Frodingham Steel Works, who has been appointed to the position of works manager to the Shelton Iron, Steel and Coal Company, Limited, Stoke-on-Trent, has been the recipient of a presentation from the officials and men at Scunthorpe.

MR. CHARLES H. LUKE has severed his connection with "The Engineering Review," both as a director and manager. In future he will devote himself entirely to trade and other exhibition work, and at present is connected with schemes in London, Paris, Glasgow, Manchester, Sheffield, etc. Mr. Luke is joint managing director of Walter Cawood, Limited, the well-known firm of exhibition organisers.

MR. J. M. ALLAN, managing director of R. & W. Hawthorn, Leslie & Company, Limited, St. Peter's, Newcastle-on-Tyne, has been elected managing director of Cammell, Laird & Company, Limited. Mr. Allan is well known in the engineering world, and has long been connected with Messrs. Hawthorn, Leslie & Company. In 1900 he was appointed to the position of general manager, and subsequently succeeded Mr. Frank Marshall as managing director.

GREAT regret was expressed in engineering circles on the announcement on September 30 of the disappearance of Dr. Rudolf Diesel, the inventor of the well-known Diesel engine, while on his way to London from Ghent to attend the annual meeting of the shareholders of the Consolidated Diesel Engine Manufacturers, Limited. Dr. Diesel was travelling with Mr. George Carels and the chief engineer of the Carels Company on the steamer "Dresden," and about ten o'clock at night he retired to his cabin. In the morning he could not be found, and the idea is that he must have fallen overboard.

New Companies.

G. & V. R., LIMITED.—Capital £10,000 in £1 shares, to carry on the business of ironfounders.

WALTER TATLOW, LIMITED.—Capital £3,000 in £1 shares to carry on the business of ironfounders, etc.

WADSWORTH & SCHOFIELD, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of ironfounders.

JONES, BURTON & COMPANY, LIMITED.—Capital £15,000 in £1 shares, to carry on the business of engineers, etc.

GREEN ENGINE COMPANY (1913), LIMITED.—Capital £50,000 in £1 shares. Registered office: 166, Piccadilly, W.

MECHANICAL ENGINEERING PATENTS, LIMITED.—Capital £5,000 in £1 shares, to adopt an agreement with W. V. Gilbert.

WOOLNOUGH LANG, LIMITED.—Capital £5,000 in £1 shares (1,000 founders). Registered office: St. Stephen's Engineering Works, St. Stephen's Street, Norwich.

HURD COAL CUTTER AND ENGINEERING COMPANY, LIMITED.—Capital £4,003 in £1 shares (4,000 preference), to carry on the business of engineers, ironfounders, etc.

CRAMP ENGINEERING COMPANY, LIMITED.—Capital £2,000 in £1 shares (500 preferred, 750 preferred ordinary, and 750 deferred ordinary). Registered office: 12, Union Street, Coventry.

HYFLO-GOULD, LIMITED.—Capital £4,200 in 4,000 ordinary shares of £1 each and 4,000 founders' shares of 1s., to carry on the business of general engineers. Registered office: 12, Theobald's Road, W.C.

SIMKINS & HADLEY, LIMITED.—Capital £10,000 in £1 shares, to take over the business of general lock manufacturers, keysmiths, engineers, etc., carried on by C. Hadley, C. H. Simkins, and W. E. Simkins, at Baltic Works, Union Street, Willenhall, as Simkins & Hadley.

BROWN & PARSONS (1913), LIMITED.—Capital £20,000 in £1 shares, to take over the business of an electrical, mechanical and general engineers and contractors, carried on by S. Hill at 63, Parade, Leamington, in succession to Brown & Parsons, Limited. Registered office: 63, Parade, Leamington.

INCORPORATED BENEVOLENT FUND OF THE INSTITUTION OF MECHANICAL ENGINEERS.—Registered with not more than 500 members, each liable for not more than 10s. each in the event of winding-up, to carry on the business indicated by the title. The management is vested in a committee, the first members of which are M. H. Robinson, W. H. Allen, Baron Merthyr of Senghenydd, C. Hawkesley, Sir H. F. Donaldson, W. H. Maw, W. Hunter, Right Hon. Sir Wm. Mather, W. B. Bryan, E. B. Ellington, E. Worthington, and A. Huson. Registered office: Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W.

Instruction in Metallurgy at Armstrong College.

The syllabus has now been issued of the classes in the principles of metallurgy, held at the Armstrong College, Newcastle-on-Tyne, in connection with the Newcastle Branch of the British Foundrymen's Association. The syllabus is as follows:—Nature of combustion. Chemical relations of carbon and hydrogen with oxygen and air. Measurements of quantities of heat and intensities of heat. Thompson and Bomb calorimeters—chief forms of pyrometers. Brief outline of composition and properties of natural fuels. Manufacture and composition of charcoal and coke. Reduction and oxidation. Slags, fluxes, and refractory materials; sands for foundry work Construction of furnaces (shaft, reverberatory and crucible furnaces). Principal iron ores, and their composition. Manufacture of cast iron; conditions influencing composition of the iron. Grading of cast iron. Effect of carbon, silicon, manganese, phosphorus and sulphur on properties of cast iron. Segregation and crystallisation in iron alloys. A laboratory course will be held in which the students will conduct experiments and investigations illustrative of the syllabus.

ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Collieries, Ltd., Cardiff.

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"BRABY'S BALANCED BARROW."

The Handiest and Cheapest Barrow in the market. Specially designed for coal, dross, ashes, etc. Its capacity is **25 per cent. greater** than the ordinary style, yet it can be wheeled with **half the labour** and can be emptied **much more quickly.** It is a **perfectly balanced** barrow, and a full load can be **easily wheeled by a boy.**

NOTE.—This Barrow can be taken right up to mouth of furnace and the ashes drawn into the barrow direct from the furnace.

The "B.B.B."

BRABY for high grade **STEEL**
SHEETS & PLATES up to 15 FEET LONG.
RANGE of GAUGES 8 to 30 W.G.
RANGE of WIDTHS 12 to 60 in.

BRABY for improved wrought **STEEL**
BARROWS, BOGIES, TRUCKS.
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SHEETS: "EMPRESS" & "SUN" BRANDS

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Also at London, Deptford, Liverpool, Bristol, Belfast and Dublin. CONTRACTORS to BRITISH and FOREIGN GOVERNMENTS. Teleg.—"Braby, Glasgow."

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

Metals.	End Sept., 1913.	End Sept., 1912.
Iron—Scotch pig warrants ton	*60/1½	*72/1
—Middlesbro' warrants ton	54 7	67 2
—W.C. M/nos Bessemer ... ton	72/6	84/0
—Stock, Middlesbrough ...tons	173,758	278,432
Copper—Chili bars GMB ton	£74 2 6	£79 2 6
—Stock, Europe and afloat tons	28,919	47,945
Tin—English ingots ... ton	£191 10 0	£234 10 0
—Straits ... ... ton	£188 0 0	£232 0 0
—Stock, London, Holland, U.S.A., and afloat ...tons	14,673	14,185
Lead—English pig ... ton	£20 15 0	£22 17 6
Spelter—Ord. Silesian ... ton	£20 17 6	£27 5 0
Quicksilver (75lb)... bottle	£7 5 0	£8 5 0
Antimony—Regulus .. ton	£28 10 0 £30 10 0	£51 0 0 £3° 0 0
Aluminium—Ingot ... ton	£86 0 0 £30 0 0	£82 0 0

*Settlement price.

Castings.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	7 7 6	to	7 12 6
Pipes, 1½ to 2½ in.	6 12 6	to	7 0 0
,, 3 to 4 in.	6 5 0	to	6 7 6
,, 5 to 8 in.	6 0 0	to	6 2 6
,, 10 to 16 in.	6 2 6	to	—
,, 18 to 24 in.	6 2 6	to	—
Chairs	4 14 0	to	4 15 0
Floor plates (open sand)	3 10 0	to	3 12 6

Scrap.

The quotations for scrap, subject to market fluctuations, are as follows: Heavy wrought (mixed), £2 17s. 6d.; light wrought, £1 5s. 0d.; heavy cast, £3 3s. 6d.; all per ton, f.o.b., London. Copper (clean), £67 10s. 0d.; brass (clean), £44 10s. 0d.; lead (usual draft), £19 0s. 0d.; Zinc, £16 5s.0d.; all per ton delivered merchant's yards.

Deaths.

The death is announced of Mr. Herbert Smith, ironfounder, of Derby, at the age of 68 years.

The death is announced from Lille, at the early age of 45 years, of M. Armand Lee, a well-known French engineer.

The death has occurred of Mr. J. W. Brookes, of J. W. Brookes (Oldbury), Limited, ironfounders, Rounds Green, Oldbury, near Birmingham. The deceased was 53 years of age.

The death took place on September 2, after a long illness, of Mr. W. Morgan, Danygraig, Briton Ferry, at the age of 60. Deceased was the works manager of the Briton Ferry Steel Company, Limited, and had been under the company since its inception 25 years ago.

The death is announced, at the age of 81 years, of Herr Eduard Becker, head of the engineering firm of that name at Reinickendorf, Germany. In his early days the deceased was connected with Gwynnes, Limited, London, and Messrs. De Bergue, Limited, Manchester.

Mr. John Cockburn, of Glasgow, who was one of the victims of the Midland Railway disaster at St. Aisgill, was commercial manager of McGregor, Swinburne, Limited, engineers, Bridgeton. His business engagements necessitated frequent travelling, and at the time of the accident he was on his way to Sheffield.

Mr. William Weir, of William Baird & Company, Limited, died on September 21, at his residence, Adamton, Monkton, at the advanced age of 87 years. Up till about two months ago, when he was laid aside with illness, Mr. Weir maintained an active interest in the business conducted by the firm. Born at Drumpark, the deceased gentleman was a relative of the founder of the firm of Messrs. William Baird & Company, and his main interest in life was the development of that company's business, which during his lifetime grew to exceptionally large proportions.

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THE
IRON CEMENT
(Quick or slow setting grades)
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Unaffected by oil, steam, or water.

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Manufacturers of all

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Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

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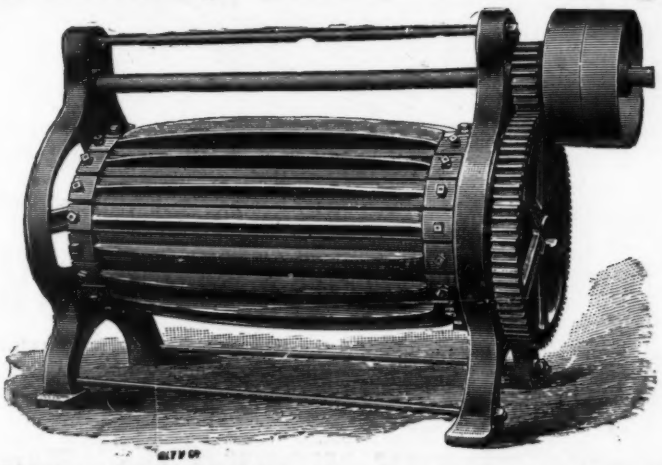

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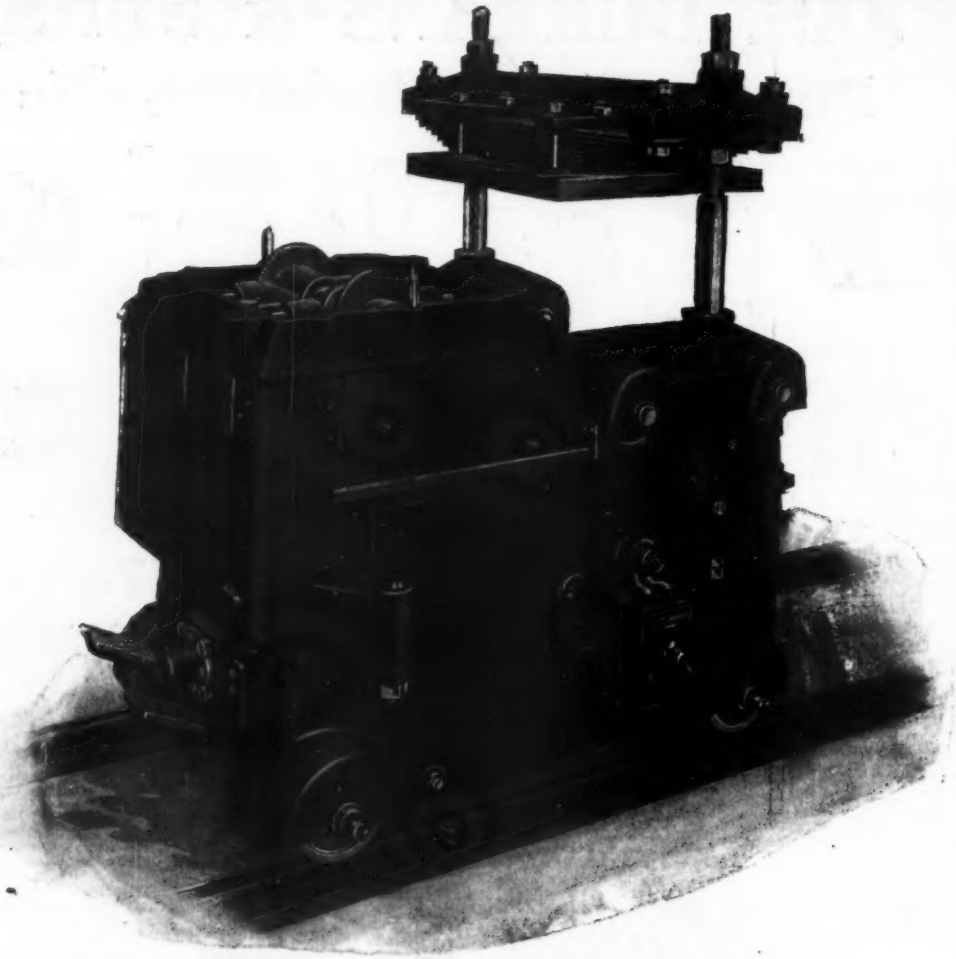

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Murphy, Stedman & Co., Ltd.

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Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Electrically Driven).
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors(Steam).
Marshall & Co., Horace P.
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Air Compressors (Belt).
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

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British Aluminium Co., Ltd.

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Tilghman's Patent Sand Blast Co., Ltd.

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Olsen, Wm.

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Olsen, Wm.
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Olsen, Wm.

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Thwaites Bros., Ltd.

THE BUYERS' GUIDE.—*Continued.*

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Marshall & Co., Horace.
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Steel Moulders' Composition.
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Evans, J., & Co.
Hall, Charles, & Co.
Olsen, Wm.

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Hall, Charles, & Co.
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Hall, Charles, & Co.
Olsen, Wm.
Wilkinson & Co., Thos., Ltd.

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Marshall, H. P., & Co.
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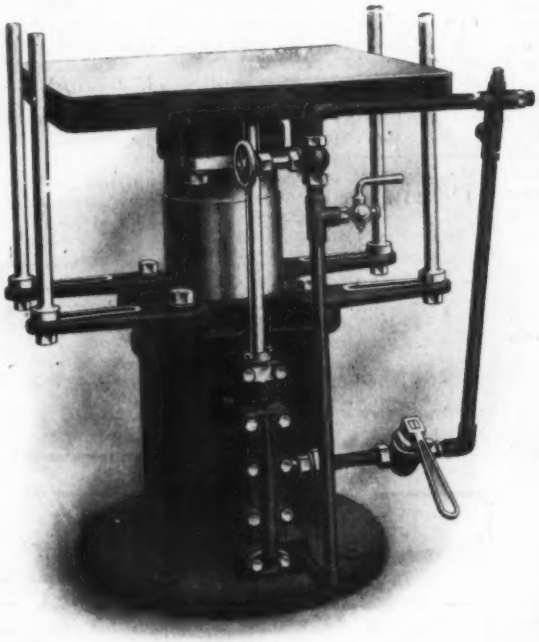

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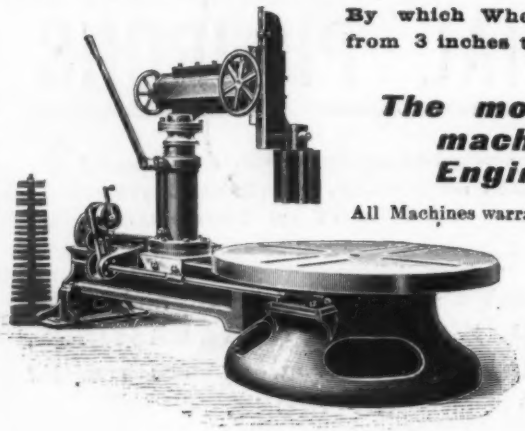

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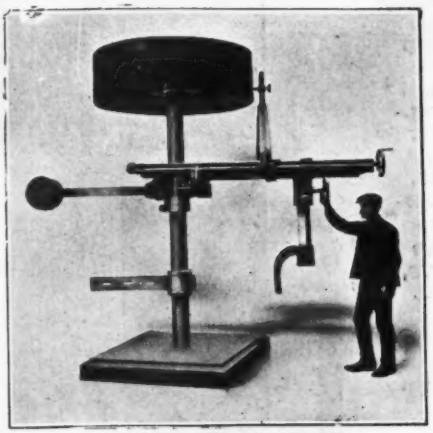

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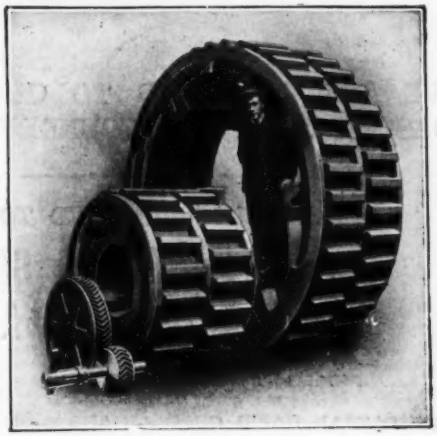

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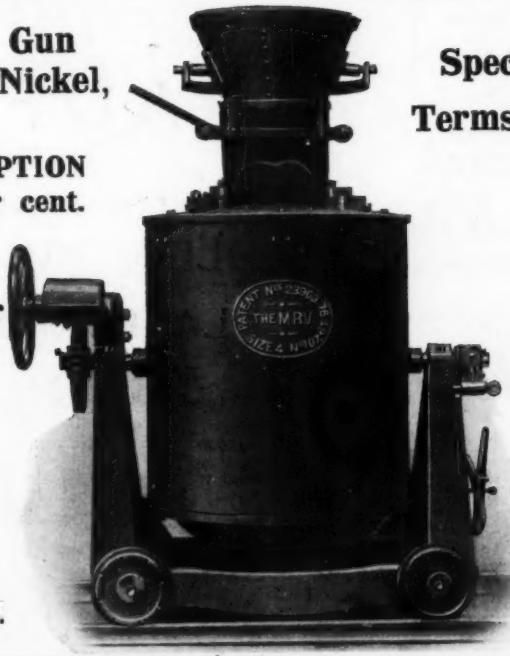

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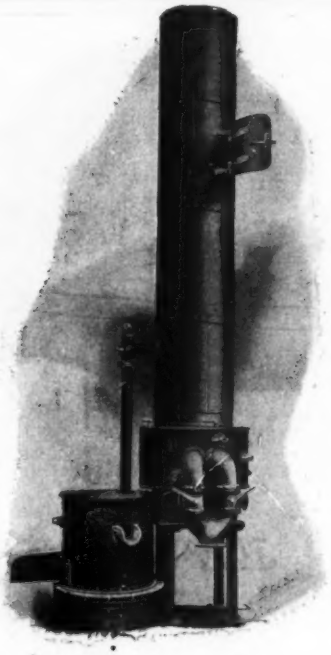

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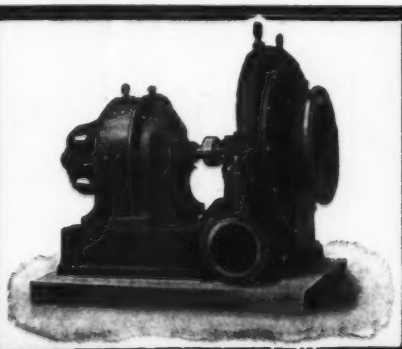

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